Aalto University
School of Business

MACROECONOMIC MOMENTUM IN THE GOVERNMENT BOND MARKET

Master's Thesis
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Finance

Autumn 2020

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Title of thesis Macroeconomic momentum in the government bond market

Degree M. Sc. in Economics and Business Administration

Degree programme Finance

Thesis advisor(s) Sami Torstila

Year of approval 2020 **Number of pages** 74 **Language** English

Abstract

I extend the literature on macroeconomic momentum – cross-sectional momentum where securities are traded according to past trends in macroeconomic fundamentals – into the government bond market and find similarities with Dahlquist and Hasseltoft's (2019) initial study on the investment strategy in the FX market. Similar to the FX market, the strategy captures a positive and robust carry factor and shows distinguishability to traditional price momentum. Unlike in the FX market, the strategy also captures a robust negative value factor highlighting the 'growth factor' nature of the strategy. However, unlike in the FX market the strategy does not generate robust positive alpha, and the market seems to heavily price-in past macroeconomic trends while in the 1990's the strategy still generated alpha in the excess of 4 % annually. While the macroeconomic momentum captures the carry and value factors, the key returns drivers are bond market and FX exposures, potentially limiting the attractiveness of the investment strategy to other investors than FX investors.

Keywords Macroeconomic momentum, government bonds, investment strategy

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Työn nimi Makroekonominen momentum valtionlainamarkkinoilla

Tutkinto KTM

Koulutusohjelma Rahoitus

Työn ohjaaja(t) Sami Torstila

Hyväksymisvuosi 2020 **Sivumäärä** 74 **Kieli** Englanti

Tiivistelmä

Laajennan tutkimusta makrotaloudellisesta momentumista - sijoitustrategiasta, jossa arvopapereilla käydään kauppaa makrotaloudellisten trendien mukaisesti – valtionlainamarkkinoille. Löydän yhtäläisyyksiä Dahlquistin ja Hasseltoftin (2019) tutkimuksen kanssa, mikä tukee väitettä omaisuusluokkarajojen ylittävästä strategiasta. Samoin kuin valuuttamarkkinoilla, strategialla on positiivinen ja tilastollisesti merkittävä carry-kerroin ja se on erotettavissa perinteisestä hintamomentumista. Toisin kuin valuuttamarkkinoilla, strategiassa on myös vahva negatiivinen arvokerroin, joka korostaa strategian potentiaalista luonnetta kasvusijoittamisen strategiana. Toisin kuin valuuttamarkkinoilla, strategia ei kuitenkaan tuota uskottavaa positiivista alfaa, ja markkinat näyttävät voimakkaasti hinnoittelevan menneitä makrotaloudellisia trendejä, kun taas 1990-luvulla strategia tuotti vielä yli 4%:n alfaa vuodessa. Vaikka sijoitusstrategia osoittaa piirteitä sekä carry- että arvokertoimesta, sen tärkeimmät tuottotekijät ovat markkinoiden systeeminen riski ja valuuttakurssiriski, mikä saattaa rajoittaa sijoitusstrategian houkuttelevuutta muiden kuin valuuttasijoittajien kannalta.

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1 Introduction

The government bond market is strongly influenced by macroeconomic factors and monetary policy which is why they are an attractive option to expand the research of macroeconomic momentum which is inspired by Dahlquist and Hasseltoft (2019) who find that investing according to past trends of macroeconomic indicators generates excess returns that are not explained by conventional FX trading strategies and risk factors. They argue that their results are heavily impacted by monetary policy and the introduction of Taylor rules in the 1990's which bound macroeconomic indicators more tightly to monetary policy implementation and future short-term interest rates.

The pricing of government bonds is eventually dependent on the term structure, i.e. yield curves which serve a role in pricing market participants' expectations of the economic outlook and the market has been increasingly affected by monetary policy as central banks have introduced quantitative easing programs. Generally speaking, steeper yield curves price a strong outlook while an inverted curve, i.e. downward-sloping curve, has been shown to predict recessions. This indicates that the pricing of government bonds is heavily dependent on expectations on macroeconomic indicators which are affected by past and current performance of those indicators. (Andersen, Rasmussen, 2003) The slope of the yield curves also captures the carry factor which predicts future returns positively as is shown by Koijen et al (2016). Based on the sovereign bond markets sensitivity to macro factors and monetary policy, there's an indication that macroeconomic momentum is also found in the government bond market similar to the FX markets.

I show that the macroeconomic momentum strategy has potential to outperform the value-weighted market index in mean annualized excess returns as well as risk-adjusted returns, while the outperformance is mainly limited to the inflation measure portfolio and currency-unhedged returns, and when hedged for FX exposure the strategy constantly underperforms the market benchmark and does not generate robust positive alpha similar to when the strategy is implemented in the FX markets. However, the linear regression results show that the returns of the macroeconomic momentum portfolios are robustly explained by zero-cost factor portfolios of carry and value similar to the findings of Dahlquist and Hasseltoft (2019) in the FX markets through taking long positions in steep sovereign yield curves and short positions in interest rate trend reversals. These factors do explain mostly only a slight portion of the strategy returns while the strategy portfolios have significant exposure to the market index, unlike a normal long-short portfolio. Therefore, I conclude that the macroeconomic momentum effect is priced-in in bond market factors.

Next, I present a summary of previous literature that serves as the base for my arguments. Then I will show my research questions and hypotheses followed by the summary of data and methodology I use. Analysis is done for both currency-hedged and unhedged returns to analyze the performance potential of the strategy while also controlling for FX exposure and having an insight on, whether the returns are based on bond market factors which could indicate the existence of macroeconomic momentum in the government bond markets.

2 Literature review

2.1. Macroeconomic momentum

Macroeconomic momentum is a form of cross-sectional momentum which bases its investment allocations on past macroeconomic trends of economies. The work of Dahlquist and Hasseltoft (2019) is currently the only study on macroeconomic momentum that has been published in academic journals. They show that making investment decisions at the end of each month based on the past trends of economic activity and inflation indicators of an economy produces a portfolio of foreign currencies which outperforms the conventional FX trading strategies of carry, price momentum and value trading with the macroeconomic momentum measure of inflation generating annualized excess returns of 3.28 % compared to that of carry trading, 3.09 %, price momentum, 1.61%, and value trading 2.58 %. In addition to outperforming the conventional strategies in mean annualized returns, Dahlquist and Hasseltoft find that the macroeconomic momentum portfolios outperform conventional FX trading strategies also in risk-adjusted returns as the inflation measure and combo measure, which combines inflation and economic activity indicators, generate annualized Sharpe ratios of 0.66 and 0.71 compared to 0.57, 0.25 and 0.42 those of carry, price momentum and value respectively.

They also find that allocating investment in foreign currencies according to the country rankings produces an economically and statistically significant alpha which is not entirely explained by carry, momentum nor value trading which means that macroeconomic momentum potentially generates returns from a unique source of risk, even as it reacts to several factors similarly to a carry strategy, e.g. liquidity and volatility shocks. This also highlights that macroeconomic momentum is independent from price momentum. The annualized alpha reaches 1.36 % when regressed with FX carry, price momentum and value with carry being the only statistically significant factor with a positive coefficient while value and price momentum load slightly negative and statistically insignificantly. Also, when regressed with factor-mimicking portfolios, as in Menkhoff et al. (2012) with five carry-sorted currency portfolios, liquidity risk premium, market volatility premium nor currency volatility premium can diminish the alpha as it stands statistically significant and economically significant at annualized 1.37 % while the factor-mimicking portfolios are statistically significant with negative coefficients in currency volatility and liquidity risk and near zero coefficient in market volatility.

The source of the performance stems from the fact that the relative rankings of economies based on past average growth and decline rates of industrial production, retail sales, inflation, producer prices and the inverse of unemployment have statistically significant predictive power in forecasting currency returns against the U.S. dollar according to Dahlquist and Hasseltoft. The predictive power of the macroeconomic momentum combo measure also subsumes that of FX carry. They account the predictiveness on Molodtsova and Papell's (2009) finding that Taylor-rule fundamentals started to predict changes in exchange rates in the 1990's when central banks started to follow Taylor rules more closely. In conclusion, Dahlquist and Hasseltoft (2019) present carry and monetary policy to be the most probable underlying factors which influence the overperformance of macroeconomic momentum in FX, while further research in macroeconomic momentum in other asset classes is encouraged to find evidence for the possible cross-sectionality of its nature.

2.2. Government bond markets

In this sub-chapter I present pieces of previous literature that give arguments on the connection of past macroeconomic fundamentals and government bond pricing, especially the term structure of interest rates as all government bond pricing is linked to it. The government bond market is a logical extension to FX markets when considering further research in macroeconomic momentum based on Dahlquist and Hasseltoft's (2019) findings as the pricing in these securities is heavily influenced by macroeconomic factors and for the past years also increasingly impacted by monetary policy as the most influential central banks have started quantitative easing programs buying government bonds for trillions of dollars to open a new transmission channel for their monetary stimulus.

The steepness, or slope, of sovereign yield curves is commonly interpreted as the strength of an economies macroeconomic outlook. Probably one of the most notable pieces of literature that highlight this is the logistic model presented in the New York Fed's journal "Current Issues in Economics and Finance" by Estrella and Mishkin (1996) who find that inversions of the U.S sovereign yield curve between maturities of 10 years and 3 months predict recessions within the following 12 months. The model has become widely used by market participants in assessing the possibility of future economic crashes because of its relative simplicity, historical accuracy and availability. Estrella and Trubin (2006) give further arguments to the robustness of the yield curve predictor when the inversion is observed on a monthly frequency and persistently but the real drivers of this predictiveness are not found robustly. They conclude that a probable driver of the predictiveness are the interactions between short-term money market rates and monetary policy influence as the yield spread indicator for future recessions is found to be independent of the movements of long-term yields.

In addition to Estrella and Mishkin the evidence of yield curve steepness and macroeconomic outlook is vastly presented in the previous literature. Smets and Tsatsaronis (1997) find that the predictive ability of sovereign yield curve steepness and macro outlook is influenced by monetary policy while real macroeconomic shocks alone do not contribute to the predictive power of yield curve steepness on economic outlook. Estimates of future inflation rates are also embedded in the slope of sovereign yield curves as Frankel and Lown (1994) show that the slope of the yield curve positively predicts the difference between 3-month and 12-month inflation rates during 1960-1991.

The amount of literature on yield curve dynamics and forecasting is vast. Vasicek (1977) lays the foundations of yield curve modelling with a one-factor model of short-term rates which is the first interest rate model that incorporates mean reversion of interest rates. Cox, Ingersoll and Ross implement an extension of the Vasicek model (CIR model) by limiting interest rate movements only to market risk. Hull and White (1990) elaborate on the CIR model by adding that the drift term of short-term interest rates is time-dependent. Ho and Lee (1986) implement a similar one-factor model of short-term rates as Vasicek with a time-drift drift term. Diebold and Li (2003) suggest a three-factor autoregressive model of level, slope and curvature which efficiently fits into market-based yield curves. One of the most widely used interest rate models is that of Nelson and Siegel (1987), their model defines a yield as the long-term level of interest rates plus short-term and medium-term components that are affected by a decay parameter.

Diebold, Li and Yue (2007) extend the Nelson-Siegel (1987) and Diebold-Li (2006) yield curve models to a global setting and find that sovereign yield curves are affected by global slope and level factors that are economically significantly influenced by macroeconomic fundamentals, more specifically inflation and real activity. Fabozzi, Martellini and Priaulet (2005) show that the sovereign yield curve slope is statistically and economically significantly predictable by credit default spreads, equity volatility and short-term as well as forward rates, which all are affected by the prevailing and past trends of macroeconomic conditions and monetary policy. De Lint and Stolin (2003) show that the leading indicator property of the term spread (LIPTS), the macroeconomic forward-looking component of the yield curve slope, is justified by a macroeconomic model with endogenous production. Additionally, Bernadell, Coche and Nyholm (2005) find in simulating a regime-switching model that long-term expectations of investors on macroeconomic fundamentals predict sovereign yield curve slope and level.

There are two hypotheses that have widely been used in explaining term structures, namely the expectations hypothesis and the liquidity preference hypothesis as well as its variations. The expectations hypothesis states that term structures are mainly driven by the expectations of short-term rates in the future while the liquidity preference theory says that the main components in term structures are risk premia. Empirical evidence is vastly against the expectations hypothesis. Ilmanen and Iwanowski (1997) find evidence that the “pure” version of expectations hypothesis fails to explain term structures probably due to time-varying risk premia and that forward-looking short-term rate expectations tend to be irrational. Sarno, Thornton and Valente (2003) find empirical evidence that leads to the rejection of the expectations hypothesis as an explanation for sovereign term structure in the U.S. while Guidolin and Thornton (2008) explain that the failure of the expectations hypothesis is due to the market participants’ inability to predict short-term rates into the future. The competing liquidity preference theory however has empirical ground as depicted by e.g. McCulloch (1975) and Longstaff (2003) who find evidence of major liquidity risk premia in sovereign yields, Bernoth, von Hagen and Schuknecht (2004) find that sovereign risk premia, i.e. government default risk premia, and liquidity risk premia are drivers of yield spreads between economies and that the introduction of the European Monetary Union (EMU) reduced the liquidity premia of its members’ sovereign debt significantly. Hautsch,and Ou (2009) find that a dynamic Nelson-Siegel type curve factor model explains future bond excess returns with volatility premium which is induced by the slope and curvature of the yield curve, i.e. interest rate risk. García and Werner (2010) show that uncertainty around inflation expectations influences inflation risk premia in yield curves, however Christensen, Lopez and Rudebusch (2010) find that long-term inflation expectations are anchored in the yield curve and the inflation risk premia have been close to zero during the first decade of the 21st century. Driessen et al. (2000) find that on average 46.6 % of variation in currency-hedged sovereign bond returns and 27.5 % of variation in currency-unhedged sovereign bond returns are explained by a “global level” factor, which is very similar to a market factor, and 44.3 % of variation in currency-hedged sovereign bond returns and 26.9 % of variation in currency-unhedged sovereign bond returns are explained by country-specific level factors while steepness factors explain on average 2-8 % of variation in sovereign bond returns. For currency-unhedged sovereign bond returns, FX factors should account on average for 28.7 % of return variation.

The sub-chapter has presented reasons to believe past macroeconomic fundamentals have an impact in the pricing of government bonds by mainly affecting several risk premia which vary over time. Next I'm going through the literature about the benchmark zero-cost portfolios of carry, momentum and value which capture different risk premia, and I will especially link the definition of carry into the concept of yield curve slope.

2.3 Bond carry, momentum and value

Carry has been almost exclusively been studied in the FX markets where it has been found to violate the uncovered interest parity (UIP) hypothesis constantly and generate extensive excess returns by shorting low-yielding currencies and taking long positions in high-yielding currencies. Koijen, Moskowitz, Pedersen and Vrugt (2018) break the exclusivity of carry as an FX factor and apply the profitable concept in several other asset classes, such as government bonds, and find that it is a cross-sectional phenomenon which generates positive excess returns in each asset class. They define carry as a component of realized returns followingly:

(Eq. 1) $$\text{Return} = \text{Carry} + \text{Expected returns} + \text{Unexpected price shock}$$

They calculate carry generally on the assumption of constant spot prices, that does not however affect the returns they report, as the forward excess returns where C_t denotes carry at time t, S_t the spot price at time t, and F_t the forward price:

(Eq. 2) $$\mathrm{C_t} = \frac{\mathrm{S_t - F_t}}{\mathrm{F_t}}$$

However, for finite-maturity securities they use the spot price of a fixed income security that has rolled down the yield curve one period, i.e:

(Eq. 3) $$\mathrm{C_t^t} = \frac{\mathrm{S_t^{t-1} - F_t^t}}{\mathrm{F_t^t}}$$

Where the upper index denotes the maturity of the security. This adjustment is made to account for roll-down as it wouldn't be appropriate to assume constant spot prices along the yield curve. The carry for bonds can be approximated as the difference of slope and roll-down as follows:

(Eq. 4) $$\mathrm{C_t^t} \sim (\mathrm{y_t^t} - \mathrm{r_t^f}) - \mathrm{D^{mod}}(\mathrm{y_t^{t-1}} - \mathrm{y_t^t})$$

Where y_t^t equals to the yield of the security with time t until maturity, r_t^f the risk-free rate and D^{mod} the modified duration of the security. The first additive term represents the slope and the second term roll-down along the yield curve. When considering carry factors of different maturity securities, the carry factor of each security is weighted according to its Macaulay duration followingly:

(Eq. 5) $$\mathrm{C_t^t}\,(\mathrm{X} = \mathrm{F_t^t D_t^t}) = \frac{\mathrm{C_t^t(X = F_t^t)}}{\mathrm{D_t^t}}$$

Where the term on the left-side of the equation equals to the duration weighted carry factor, and the nominator of the fraction on the right-side denotes the carry calculated in Eq. 3. They find that slope alone receives a 0.91 coefficient estimate when predicting next month's carry factor with a single-factor linear regression model.

In general, they find that carry in other asset classes shows similar exposure to downside risks for liquidity, volatility and business cycle shocks to FX markets where the factor has been studied extensively. However, carry returns cannot be explained entirely by these factors even while they load on them economically and statistically significantly. In FX, carry has been linked to macroeconomic risks such as aggregate consumption risk as in Hoffmann and Studer-Suter (2017), growth shocks as in Colacito, Croce, Gavazzoni and Ready (2018) and foreign exchange volatility in addition to market-wide volatility as in Menkhoff, Sarno, Schmeling and Schrimpf (2012).

In addition to carry, also the concepts of price momentum and value can be applied to fixed income as is found in Asness, Moskowitz and Pedersen's (2013) study. For momentum they use the lookback period of 2-12 months, i.e. 11-month returns that are lagged by one month as to decrease the possibility of liquidity issues posing outlier risk. This same momentum measure is used broadly in momentum literature, e.g. Fama and French (1996) which included the momentum factor into their famous three-factor model of equity pricing. The bond value factor of Asness et al. (2013) is simply the five-year change of the 10-year benchmark bond yield of a country. This measure is constructed as to promote simplicity and transparency, but it still has scientific backing as Fama and French (1996) show that sorting stocks into portfolios according to their negative past 5-year returns produces portfolios that are highly correlated with portfolios formed by the book-to-market ratio, i.e. equity value factor. Asness, Moskowitz and Pedersen (2013) consider also an alternative method of measuring the value signal with the 5-year yield change, however it yields similar results.

Based on the review of past literature, I next present my research questions and hypotheses on the macroeconomic momentum effect in the government bond markets.

3 Research questions and hypotheses

Based on the findings of Dahlquist and Hasseltoft (2019) and also on the vast amount of literature that government bond yields are a function of macroeconomic indicators and yield curve slopes are forward-looking in expected macroeconomic conditions, as well as influenced by the implementation of monetary policy (Smets et al. 1997), which Dahlquist and Hasseltoft argue being the driver of macroeconomic momentum returns, I suggest that macroeconomic momentum is found in the government bond market as well.

I expect that bond carry will be a significant driver of the excess returns produced by macroeconomic momentum as Koijen et. al (2018) show that bond carry is an approximation of the slope and rolldown on the yield curve and stronger macroeconomic outlooks – driven commonly by past strong macroeconomic trends (Andersen et al, 2003) – lead to steeper yield curves and therefore higher roll-down returns. Also, as the yield spread, i.e. slope of the yield curve, is to be found a significant predictor of carry, I expect the macroeconomic momentum strategy in government bonds to have a high impact from the carry factor. There's also evidence from the FX markets that carry returns are influenced by macroeconomic risks as in Hoffmann and Studer-Suter (2017) and Colacito, Croce, Gavazzoni and Ready (2018) and carry loads economically and statistically significantly in explaining FX macroeconomic momentum returns.

Dahlquist and Hasseltoft (2019) find that the FX strategy performs well during times of market stability and poorly during liquidity and volatility spikes, which indicates that performance of macroeconomic momentum in the government bond markets stems from the yield curve retaining its steepness through time, and this should be seen as a positive carry coefficient in the regressions. I expect that especially the inflation measure returns will have a significant impact from the carry factor, as long-term inflation expectations are embedded in yield curves (Christensen et al, 2010) and past and current inflation rates correlate positively with inflation expectations (Fisher, 1925 and 1930). The positive carry coefficient should be accompanied by a negative value coefficient as the macroeconomic momentum strategy should have most of the time a short position on the bonds the value strategy has long positions and vice-versa, i.e. the value factor is long on mean-reversion of interest rates (Asness et al, 2013) while I expect the macroeconomic momentum to have a short position on it on average. If the value factor loads robustly, it is contradicting to Dahlquist and Hasseltoft (2019), but which stems from the differences of the factor's calculation methodology in FX and bonds.

With short-term lookbacks I expect the carry coefficient being lower and value factor stronger as those can capture trend reversions, for longer lookbacks the yield curve has more time to adjust to positive trends and economic outlook which is why I expect that the longer lookbacks have a higher coefficient for carry. Price momentum is found to be different to macroeconomic momentum in the FX markets by Dahlquist and Hasseltoft (2019), which is why I don't expect it to play a significant role in explaining the macroeconomic momentum returns. Given that Driessen et al. (2000), accompanied with a similar results by Dieblod et al. (2007), find that about half of currency-hedged return variation and about a quarter of currency-unhedged returns variation is explained by a "global level" factor, I expect the market factor to be a significant return driver, even as the strategy is executed through a long-short portfolio that should be more or less market-neutral.

I expect the inflation measure to perform better than the economic activity measure based on the fact that the inflation measure performance is superior compared to the economic activity measure in the FX markets, and inflation rates affect monetary policy strongly as most central banks in my sample have a goal to target inflation. Monetary policy influences the predictive power of the yield curve slope in predicting future economic conditions and real economic activity shocks have little impact on it as in Smets and Tsatsaronis (1997), and that Frankel and Lown (1994) and Christensen et al (2010) show that inflation expectations are embedded in yield curves. Also, the simple and effective model of Fisher (1925 and 1930) finds that past and current inflation predicts inflation expectations. Summarized, past and expected inflation trends should affect yields more than past and expected economic activity trends.

Since there is no other previous literature on macroeconomic momentum than Dahlquist and Hasseltoft's (2019) paper I will keep the test setting as similar as possible to theirs with the addition of some emerging market economies to the sample and a shorter timeframe from 1/1989 until the end of April 2020. I will test the drivers of macroeconomic momentum returns in government bonds with similar zero-cost factors as Dahlquist and Hasseltoft do with the currency macroeconomic momentum returns - namely carry, price momentum and value - as there is evidence from Koijen et. al (2018) and Asness (2013) that these factors are found in other asset classes than FX as well. To control for FX exposure and to find similarities between the macroeconomic momentum strategies in FX and government bond markets, I will analyze currency-unhedged and currency-hedged portfolio returns separately and include them to the dependent variables to avoid multicollinearity issues. All returns are denominated in USD, similar to Dahlquist and Hasseltoft (2019). To control for the typical government bond market risk factors such as duration risk i.e. interest rate risk, inflation risk, reinvestment risk and sovereign risk I will also include a monthly-rebalanced value-weighted benchmark index, which consists of the investment universe, i.e. government bonds of the selected countries, into the independent variables. This is also a slight extension to the test setting of Dahlquist and Hasseltoft (2019) as they only have zero-cost factor portfolios as independent variables in their linear regression models, which is mostly due to the FX markets lacking a clear market factor unlike e.g. the government bond market and equity markets. Since typical market-wide risk factors such as volatility risk and liquidity risk should be loaded into the carry factors since there is broad evidence of carry being highly influenced by negatively skewed events in these risk factors, I will not include them as separate variables.

3.1 Hypotheses and predictions summarized

To sum it up, first I will answer the question whether the macroeconomic momentum investment strategy outperforms in the government bond universe compared to a value-weighted market index, then test whether the bond factor portfolios of market, carry, momentum and value drive the macroeconomic momentum portfolio returns similar to Dahlquist and Hasseltoft's findings in the FX markets.

- I expect the market factor to be a significant driver of excess returns as sovereign yields correlate highly with a 'global' factor (Diebold et al, 2007, Driessen et al, 2000).
- I expect the inflation macroeconomic momentum measure, where the investment allocation is done based on past inflation trends, to outperform the economic activity measure due to previous literature having found that inflation factors affect the yield curve more significantly than real economic output factors. (Smets et al, 1997)
- I expect carry being captured by the macroeconomic momentum returns due to the strategy performing well in the FX markets and because past macroeconomic trends translate into steeper yield curves, which are the return driver of bond carry returns. (Christensen et al, 2010, Dahlquist et al, 2019, Fisher 1925 and 1930, Frankel et al, 1994, Koijen et al, 2018)
- I also expect that the value factor receives a negative coefficient due to the investment allocation being based on past trends, not e.g. mean reversion. (Asness et al, 2013)
- Price momentum should be distinct from macroeconomic momentum, i.e., I expect them to have weak correlation. (Dahlquist et al, 2019)
- I expect that short-term lookback returns are more driven by the market and FX exposure while longer lookback returns capture a positive carry and negative value factor.

4 Data

4.1 Macroeconomic data

To form the fundamental indices of inflation, economic activity and combo, as in Dahlquist and Hasseltoft's (2019) paper about macroeconomic momentum in FX, I collect the macroeconomic data from the OECD Database for the time period 9/1983 – 12/2019, which is needed to calculate portfolio weights for lookback periods of up to 60 months with a 3-month lag. The consumer prices, producer prices, industrial production, retails sales and unemployment are collected for 27 countries: the United Kingdom, Switzerland, Japan, Canada, Australia, New Zealand, Sweden, Norway, Denmark, Germany, France, Italy, Spain, Portugal, Austria, Belgium, the Netherlands, Ireland, Finland, Poland, the Czech Republic, Hungary, South Korea, Mexico, South Africa and the United States. To minimize selection bias the countries are selected purely by the basis of data availability in the necessary data series of bond indices as well as currency spot rates, forward points and benchmark government bond yield data which are needed in my methods.

The industrial production, retail sales and unemployment data series are seasonally-adjusted and the unemployment measure harmonized. The unemployment data is later inversed to create the economic activity and combo fundamental indices. All the data series except unemployment are indices which are updated monthly except for some countries and indicators which are updated quarterly. Quarterly data is interpolated into monthly frequency by filling the missing monthly observations with the latest quarterly observation, which is a similar method as Dahlquist and Hasseltoft (2019) use to clean the data. The data start for each country varyingly with most countries having observations in each of the 5 indicators by the end of the 1980's, but latest by 2002 if South Africa is excluded as they only have data available for retail sales and the inflation indicators. The beginning point of the latest-starting indicator does not however defer the possibility of forming portfolio weights for countries as all available data is used at any point in time to form them. This means that if a country has any data available for any of the fundamental indices, which are discussed in the **Section 5.1**, the index will be formed for that country. **Table 1** summarizes the availability of the macroeconomic data by country and indicator.

Table 1. Starting months of the macroeconomic indicator data by country, CPI = consumer price index, PPI = producer price index

	Retail Sales	Industrial Production	CPI	PPI	Unemployment
Australia	9/1983	9/1983	9/1983	9/1983	9/1983
Austria	9/1983	9/1983	9/1983	1/2000	1/1993
Belgium	9/1983	9/1983	9/1983	9/1983	9/1983
Canada	9/1983	9/1983	9/1983	9/1983	9/1983
Czechia	1/1996	1/1990	1/1991	1/1990	1/1993
Denmark	9/1983	9/1983	9/1983	9/1983	9/1983
Eurozone	1/1995	9/1983	1/1996	1/1985	1/2000
Finland	9/1983	9/1983	9/1983	9/1983	1/1988
France	9/1983	9/1983	9/1983	9/1983	9/1983
Germany	9/1983	9/1983	9/1983	9/1983	1/1991
Hungary	1/1992	1/1985	9/1983	1/1995	1/1996
Ireland	9/1983	9/1983	9/1983	9/1983	9/1983
Italy	1/1990	9/1983	9/1983	1/1991	9/1983
Japan	9/1983	9/1983	9/1983	9/1983	9/1983
Mexico	1/1986	9/1983	9/1983	9/1983	1/1987
Netherlands	9/1983	9/1983	9/1983	9/1983	9/1983
New Zealand	9/1983	9/1983	9/1983	9/1983	3/1986
Norway	9/1983	9/1983	9/1983	9/1983	1/1989
Poland	1/1991	1/1985	1/1989	1/1995	1/1997
Portugal	1/1990	9/1983	9/1983	9/1983	9/1983
South Africa	9/1983	-	9/1983	9/1983	-
South Korea	1/1990	1/1989	9/1983	9/1983	1/1990
Spain	1/1995	9/1983	9/1983	9/1983	4/1986
Sweden	9/1983	9/1983	9/1983	9/1983	9/1983
Switzerland	9/1983	9/1983	9/1983	6/2002	6/1999
UK	9/1983	9/1983	9/1983	9/1983	9/1983
USA	9/1983	9/1983	9/1983	9/1983	9/1983

Since macroeconomic data is prone to revisions and lagged releases (e.g. industrial production data for March is published in May), which are challenging to trace historically, I add a 3-month lag from the point in time when the investment signals are formed until the actual allocation. This is to make sure that the historical value of a macroeconomic indicator was more likely known by the market at the time of investment. This is a similar method to Dahlquist and Hasseltoft (2019) in assessing the slight inaccuracy of historical macroeconomic data, they however add that lagging the investment decision does not alter the results significantly.

4.2 Government bond index data

The monthly bond returns are calculated from Bloomberg Barclays Global Total Return indices which are collected from Bloomberg. The indices capture both coupon yield and roll-down. The indices correspond to each country's outstanding government debt securities with at least 1 year remaining until maturity and they are rebalanced monthly according to the market value of the underlying bonds. All the bonds are fixed-rate and non-callable. In addition to index values also weighted average maturity, Macaulay duration, option-adjusted convexity, yield-to-worst and total market value are collected for each bond index. The index values represent cumulative USD-denominated returns and the indices are unhedged for exchange rate risk. Most of the bond index data is available at the beginning of the investment period in 1/1989 but the latest-starting indices of Mexico, South Africa, Poland, Hungary and the Czech Republic begin in 1/2005. The option-adjusted convexity data starts in 1997 at earliest, however I do not use the data in my main results and store it for possible later use in robustness checks.

4.3 FX market data

For the calculation of the FX macroeconomic momentum returns I collect monthly FX spot and 1-month forward points data from Bloomberg. The data represents the last trade price of each month's last trading day and all the forward points of exchange rates represent traded values even for the less liquid emerging markets currencies in my sample. I see that this mention is necessary as some less liquid cross-currency rate data from Bloomberg represent synthetic values or non-deliverable fixings. The spot rates use USD as the base currency and foreign currencies as the quote currency as some cross-currency spot rates have more data available with this setting as compared with their standard market quotation, e.g. EUR/USD, AUD/USD and NZD/USD. Most of the FX and forward points data is available at start of the investment period. The rates are later inversed to have USD as the quote currency so that increases in them are interpreted as dollar devaluation i.e. returns on USD investment, and vice versa for decreases. The 1-month forward points data is only available for the market standard quotations. Finally, I collect monthly data for the 1-month USD Libor which I use as the risk-free rate.

Table 2. Starting months of the market data by country. Bond and FX data refer to the first month when returns can be calculated, the date of benchmark 10-year yield refers to the first month there is available data of the 10-year yield.

	BBG Barclays bond index	FX spot against USD	FX 1-month forward points	Benchmark 10-year yield
Australia	1/1989	1/1988	1/1988	1/1984
Austria	1/1989	1/1988	1/1988	2/1986
Belgium	1/1989	1/1988	1/1988	3/1992
Canada	1/1989	1/1988	1/1988	1/1984
Czechia	2/2005	7/1993	7/1993	5/2000
Denmark	1/1989	1/1988	1/1988	1/1984
Finland	8/1991	1/1988	1/1988	8/1991
France	1/1989	1/1988	1/1988	2/1986
Germany	1/1989	1/1988	1/1988	1/1984
Hungary	2/2005	7/1993	7/1993	2/2002
Ireland	1/1989	1/1988	1/1988	1/1988
Italy	1/1989	1/1988	1/1988	3/1991
Japan	1/1989	1/1988	1/1988	2/1986
Mexico	2/2005	1/1988	1/1988	7/1994
Netherlands	2/1990	1/1988	1/1988	5/1986
New Zealand	1/1989	1/1988	1/1988	4/1985
Norway	5/1991	1/1988	1/1988	2/1986
Poland	2/2005	7/1993	7/1993	1/2000
Portugal	9/1991	1/1989	1/1989	11/1988
South Africa	2/2005	1/1988	1/1988	9/1983
South Korea	2/2002	1/1988	1/1988	1/2001
Spain	2/1989	1/1988	1/1988	6/1991
Sweden	1/1989	1/1988	1/1988	2/1987
Switzerland	1/2010	1/1988	1/1988	2/1988
UK	1/1989	1/1988	1/1988	1/1984
USA	1/1989	-	-	1/1984

4.4 Benchmark government bond yields

For calculating the value factor of bonds I collect monthly 10-year government bond yields for the sample countries between 1/1984 and 3/2020 from Macrobond. The yields represent the last traded value of each month. The data is on average earlier available for the 10-year yields so I prefer them over the 5-year and 3-month yields which Asness et al (2013) consider also to be adequate in calculating the value factor. **Table 2** shows a detailed summary of each country's market data availability.

5. Methodology

5.1. Macroeconomic momentum bond portfolio

The macroeconomic momentum bond portfolios are constructed similar to Dahlquist and Hasseltoft's (2019) paper by rebalancing the positions at the end of each month based on the relative strength of each country's macroeconomic trends in economic activity and inflation. I consider eurozone countries individually even after the introduction of the euro as that provides a more realistic test setting than using a single value-weighted bond index of the eurozone countries. This can be reasoned with the fact that the Eurozone has historically not been a debt-issuer itself – aside from the few bonds of the European Stability Mechanism - and that individual eurozone countries constitute a large amount of government bonds in the market.

The first step in calculating the macroeconomic momentum portfolio returns is calculating the monthly growth rates of each macroeconomic indicator and for each country. Then the average of the growth rates among the available indicators is calculated to form economic activity, inflation and combo fundamental indices for each country as in **equations 6-8**. $FI_{i,x,t}$ denotes the fundamental index i for country x at time t and the first observation month of each fundamental index is set as the basis index value (= 100).

(Eq. 6) $$\mathrm{FI}_{\mathrm{econ},x,t} = \left(\frac{1}{3}\left(\frac{\mathrm{Retail}_{x,t}}{\mathrm{Retail}_{x,t-1}} + \frac{\mathrm{Industrial}_{x,t}}{\mathrm{Industrial}_{x,t-1}} + \frac{\frac{1}{\mathrm{Unemployment}_{x,t}}}{\frac{1}{\mathrm{Unemployment}_{x,t-1}}}\right) + 1\right) * \mathrm{FI}_{\mathrm{econ},x,t-1}$$

(Eq. 7) $$\mathrm{FI}_{\mathrm{inflation},x,t} = \left(\frac{1}{2}\left(\frac{\mathrm{CPI}_{x,t}}{\mathrm{CPI}_{x,t-1}} + \frac{\mathrm{PPI}_{x,t}}{\mathrm{PPI}_{x,t-1}} + \right) + 1\right) * \mathrm{FI}_{\mathrm{inflation},x,t-1}$$

(Eq 8.) $$\mathrm{FI}_{\mathrm{combo},x,t} = (\frac{1}{5}(\frac{\mathrm{Retail}_{x,t}}{\mathrm{Retail}_{x,t-1}} + \frac{\mathrm{Industrial}_{x,t}}{\mathrm{Industrial}_{x,t-1}} + \frac{\frac{1}{\mathrm{Unemployment}_{x,t}}}{\frac{1}{\mathrm{Unemployment}_{x,t-1}}} + \frac{\mathrm{CPI}_{x,t}}{\mathrm{CPI}_{x,t-1}} + \frac{\mathrm{PPI}_{x,t}}{\mathrm{PPI}_{x,t-1}}) + 1) * \mathrm{FI}_{\mathrm{combo},x,t-1}$$

The economic activity fundamental index consists of seasonally-adjusted retail sales and industrial production indices, and of the inverse of unemployment. The unemployment indicator is inversed so that the decrease in unemployment is determined as a positive signal and increase in unemployment as a negative signal. The inflation fundamental index consists of consumer price index (CPI) and producer price index (PPI) so they can directly be interpreted as inflation in consumer prices and as inflation in producer prices. Lastly the combo fundamental index consists of all the five macroeconomic indicators.

The next step is to calculate *trend measures* for each fundamental index *i* and country *x* for time t with lookback period *j*, these are then used to form portfolio weights for the *sub-strategies*, i.e.

for each lookback. The lookback period varies from 1 to 60 months and a sub-strategy is formed for each of them, so all in all I calculate portfolio returns for three macroeconomic momentum strategies (economic activity, inflation and combo) with each of them being created equally-weighted from 60 sub-strategies that produce investment signals based on the changes between the current value of a country's fundamental index and the value *j* months earlier. As a direct example the economic activity sub-strategy with a lookback of 60 months invests in government bond indices based on the average changes of industrial production, retail sales and inverse unemployment rate of countries between the time t and 60 months earlier. The actual formulations of the definition of the trend measures can be seen below in **Equations 9-11**.

(Eq. 9) $\mathrm{TM}_{\mathrm{econ,j,x,t}} = \log(\mathrm{FI}_{\mathrm{econx,t}}) - \log(\mathrm{FI}_{\mathrm{econ,x,t-j}})$

(Eq. 10) $\mathrm{TM}_{\mathrm{inflation,j,x,t}} = \log(\mathrm{FI}_{\mathrm{inflation,x,t}}) - \log(\mathrm{FI}_{\mathrm{inflation,x,t-j}})$

(Eq. 11) $\mathrm{TM}_{\mathrm{combo,j,x,t}} = \log(\mathrm{FI}_{\mathrm{combo,x,t}}) - \log(\mathrm{FI}_{\mathrm{combo,x,t-j}})$

The trend measures are turned into portfolio weights by ranking the measures of each country cross-sectionally similar to Asness et al. (2013) and Koijen et al. (2018) resulting in positive weights for the half of the countries with stronger past macroeconomic trends and negative weights for the weaker half of countries. **Equation 12** shows the formula for calculating the portfolio weights in more detail; weight based on fundamental index i for lookback (sub-strategy) j and country x at time t equals to the relative ranking of the trend measure for fundamental index i for lookback j and country x at time t compared to other countries. a_t denotes the scaling factor which assures that weights of both long and short positions equal to 1 and X_t the number of available countries at time t.

(Eq. 12) $\mathrm{w}_{\mathrm{i,j,x,t}} = \mathrm{a}_{\mathrm{t}}[\ \mathrm{rank}\ (\mathrm{TM}_{\mathrm{i,j,x,t}} - \frac{1}{\mathrm{X}_{\mathrm{t}}} \sum_{\mathrm{x}=1}^{\mathrm{X}_{\mathrm{t}}} \mathrm{rank}(\mathrm{TM}_{\mathrm{i,j,x,t}})\ ]$

This results in a zero-cost portfolio that goes long the past "winners" and short the past "losers" and is dollar-neutral. According to Asness et al. (2013), Koijen et al. (2018) and Dahlquist and Hasseltoft (2019) this method results also in more robust portfolio weights as effects of measurement errors, revisions and data outliers are reduced. Dahlquist and Hasseltoft (2019) state that the method also potentially improves diversification as it includes all assets in the investment universe and reduces selection bias that would arise from taking positions i.e. only in the top X best and worst X performers. Finally, the excess returns of the sub-strategy portfolios at time *t + 1* equal to:

(Eq. 13) $$R_{i,j,x,t+1} = \sum_{x=1}^{X_t} w_{i,j,x,t} R_{x,t+1}$$

where $R_{x,t+1}$ is the excess return for the bond index at time t + 1 over the forward price at time t:

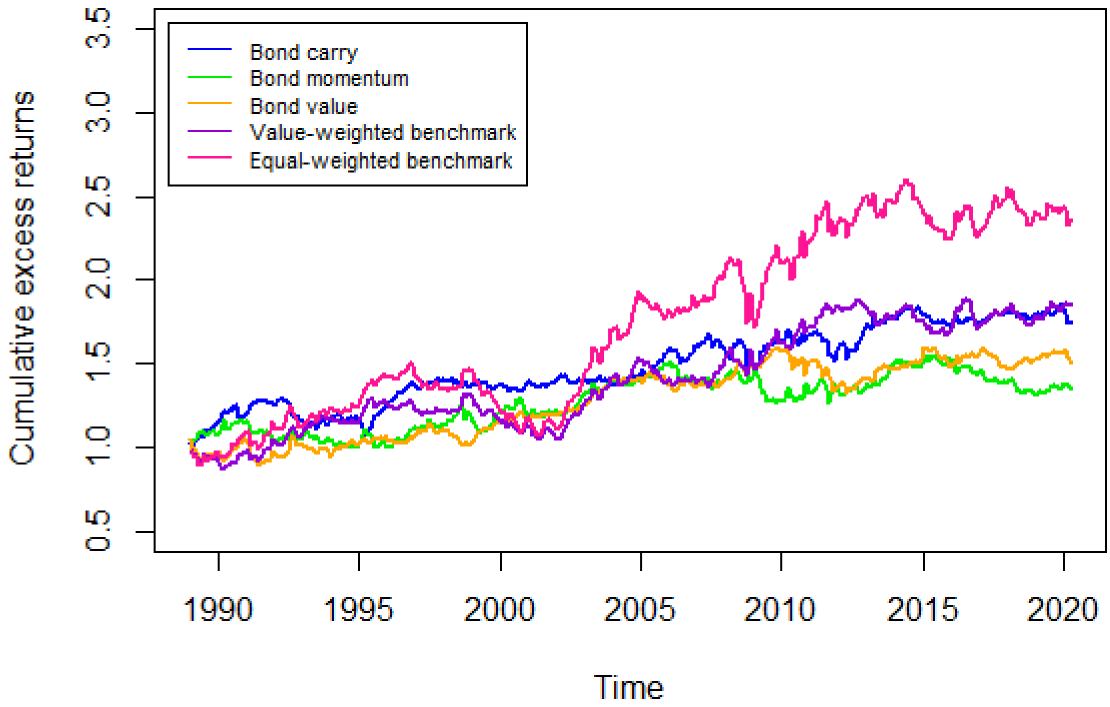
(Eq. 14) $$R_{x,t+1} = \frac{I_{bond\ index,\ t+1} - I_{bond\ index.\ t} * e^{rT}}{I_{bond\ index.\ t} * e^{rT}}$$

Where *I* is the index value, *r* is the annualized 1-month USD Libor and $T = \frac{1}{12}$. These sub-strategy portfolio excess returns are aggregated into fundamental strategy returns, i.e. economic activity, inflation and combo, by equal-weighing each sub-strategy's excess returns. Dahlquist and Hasseltoft (2019) weigh the sub-strategies with their past exponentially-weighted moving average volatility but state that a robustness check with equal-weighting results in little difference in the performance of the macroeconomic momentum investment strategies. Equal-weighing the sub-strategies should also be considered as making the setting more simple and the results more transparent.

5.2 Benchmark portfolios and their performance

I form four benchmark bond portfolios to explain the excess returns of the macroeconomic momentum return drivers: carry, price momentum, value and a monthly rebalanced market value-weighted index to reflect on the sovereign bond market's movements. I also form an equal-weighted market index from the sampled countries to compare the returns of more complex trading strategies to a simple strategy. All of the benchmark portfolios are formed in both currency-hedged and currency-unhedged forms to control for FX factors and also to analyze the total returns generated from all risk sources. **Figure 1** shows the unhedged cumulative excess returns of the benchmark bond portfolios, while **Figure 2** shows the hedged cumulative excess returns, key statistics of the monthly returns are reported in **Tables 3 and 4**.

Figure 1. Cumulative excess returns of the unhedged bond benchmark portfolios, the beginning balance of each portfolio is indexed to January 1989



The value-weighted benchmark index is formed by weighting each country-specific bond index by its relative market value compared to other country-specific bond indices at the end of each month. The index is rebalanced at the end of each month. The U.S, Japan and eurozone countries dominate the value-weighted index with weights of 30.7 %, 29.1 % and 22.7 % while the fourth G4 country, the UK, has a weight of 6.9 % at the end of 4/2020. The mean annualized excess returns of the unhedged value-weighted market index equal to 2.01 % and cumulatively during the sample period to total excess returns of 86.5 %, while the unhedged equal-weighted benchmark index generates mean annualized returns of 2.79 % and cumulatively excess returns of 136.8 %. The value-weighted index has a similar level of risk-adjusted returns to the equal-weighted index with a Sharpe ratio of 0.31 compared with the Sharpe ratio of 0.322 of the equal-weighted index. The currency-hedged benchmark indices however generate significantly higher risk-adjusted returns than the currency-unhedged portfolios with Sharpe ratios of 0.86 and 0.79 for the value-weighted and equal-weighted indices respectively, while the mean annualized excess returns of the value-weighted index increase to exceed the equal-weighted index with 2.60 % compared to 2.50 % of the equal-weighted index.

The bond carry portfolio is formed using Koijen et al.'s (2018) methodology shown in **Equations 2-5** to calculate a carry factor for each country's bond index. I use the yield-to-worst of each country-specific bond portfolio and interpolate a yield that has a maturity 1 month less than that of the portfolios. I use linear interpolation between the index yield and the 10-year benchmark yield of the country. 3-month benchmark yields could be more proper solution for this method, but unfortunately the data for those is very limited within the sample countries. Nevertheless, the returns I generate are in line with Koijen et al.'s (2018) reported returns. The risk-free rate is the 3-month USD Libor as the bond indices are denominated in USD. To form a carry portfolio, I weigh each bond index by its carry factor by the same weighing method as with the macroeconomic momentum in **Equation 12**, similar to Koijen et al. (2018) each month's weight is based on the carry factor at the end of the previous month.

Table 3. Annualized mean excess returns, standard deviation, and Sharpe ratio of currency-unhedged benchmark portfolios used in the regression model, as well as their first-order autocorrelation, skewness and excess kurtosis of monthly excess returns.

Unhedged portfolio statistics

	Bond portfolios					FX macroeconomic momentum		
	Bond carry	Bond momentum	Bond value	Value-weighted index	Equal-weighted index	Inflation	Economic activity (EA)	Combo
Mean	1.808	0.958	1.318	2.009	2.790	1.317	1.158	1.307
St. Dev.	5.588	6.447	6.086	6.460	8.676	5.934	3.699	5.021
Sharpe ratio	0.323	0.149	0.217	0.311	0.322	0.222	0.313	0.260
AR(1)	-0.036	0.036	-0.020	0.112	0.062	0.080	-0.055	0.064
Skewness	-0.627	-0.264	-0.303	0.090	-0.147	-0.545	-0.247	-0.129
Kurtosis	5.544	4.542	5.595	3.524	4.264	5.165	3.745	3.503

As seen in **Figure 1**, the unhedged bond carry returns show a very similar return pattern as depicted in the literature, with high returns during economic tranquility and sharp losses during heightened macroeconomic risk and volatility and tighter liquidity conditions. The fresh March/April 2020 COVID-19 pandemic can also be seen in the returns as a bump downwards. The unhedged excess returns of the bond carry portfolio amount to 75.3 % with mean annualized excess returns of 1.81 % as seen in **Table 4**. Out of the benchmark portfolios the unhedged carry portfolio generates risk-adjusted returns of similar size to the value-weighted market index with a Sharpe ratio of 0.32. However, the portfolios risk-adjusted returns are inflated when the exchange rate risk is hedged as seen in **Table 4**, with the Sharpe ratio of the carry portfolio rising to 0.51, which is despite lower than the hedged value-weighted market index' Sharpe ratio of 0.86. Alongside the carry portfolio, all the unhedged zero-cost portfolios show highly negative skewness while the unhedged value-weighted market index has slightly positive skewness.

The bond momentum portfolio is formed using the 1-month lagged 11-month returns of the bond indices as in Asness et al. (2013) for bond portfolios and Fama and French (1996). Portfolio weights are calculated at the end of each month similar to the bond carry portfolio and the macroeconomic momentum using **Equation 12.** The unhedged momentum portfolio generates 34.8

% cumulative excess returns since 1/1989 with a mean annualized excess return of 0.96 %, while the Sharpe ratio is the lowest of the benchmark portfolios. The hedged price momentum portfolio generates very similar mean annualized excess returns to the unhedged portfolio, 0.93 % with a higher Sharpe of 0.32 and cumulative excess returns of 33.6 %.

Figure 2. Cumulative excess returns of the hedged bond benchmark portfolios, the beginning balance of each portfolio is indexed to January 1989

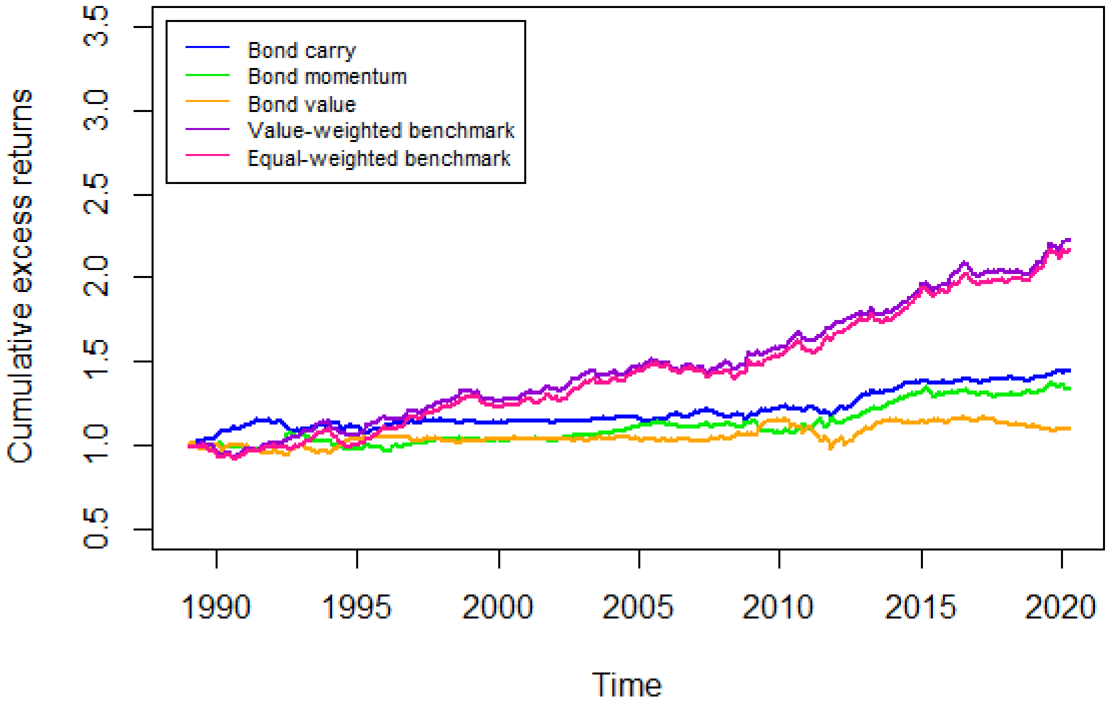


Table 4. Annualized mean excess returns, standard deviation, and Sharpe ratio of currency-hedged benchmark portfolios used in the regression model, as well as their first-order autocorrelation, skewness and excess kurtosis of monthly excess returns.

Hedged portfolio statistics

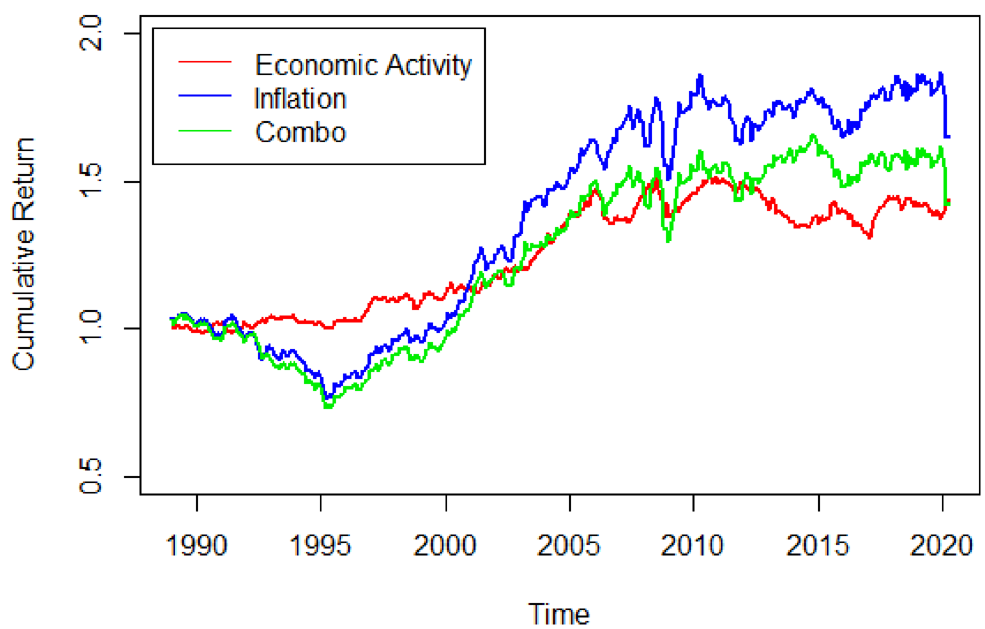
	Bond portfolios				
	Bond carry	Bond momentum	Bond value	Value-weighted index	Equal-weighted index
Mean	1.179	0.929	0.298	2.602	2.503
St. Dev.	2.325	2.941	3.013	3.030	3.158
Sharpe ratio	0.507	0.316	0.099	0.859	0.792
AR(1)	-0.012	0.085	0.030	0.186	0.179
Skewness	-0.078	0.367	-0.175	-0.071	-0.059
Kurtosis	4.839	5.847	7.771	3.262	3.119

The bond value portfolio is formed also similar to Asness et al. (2012) by ranking the bond indices based on the 5-year change in each country's 10-year benchmark government bond yield, i.e. countries whose 10-year yield has increased the most during the past 5 years are ranked higher and countries whose 10-year yield has decreased the most during the past 5 years are ranked lower. **Figure**

1 shows that the unhedged value portfolio generates cumulative excess returns of 50.7 % while the hedged portfolio generates excess returns of only 9.8 % during 376 months, which indicates that the value portfolio is the most affected by FX risk out of all the benchmark portfolios. Additionally, the value effect has been documented by Asness et. al (2013) to be relatively weak in the bond market compared to equity and FX, which could make the factor more volatile across samples. I will however still use it as a benchmark portfolio similar to Dahlquist and Hasseltoft's (2019) test setting of the macroeconomic momentum effect. The excess kurtosis of the hedged value portfolio is significantly higher than the other benchmark portfolios' which is natural for a portfolio that should benefit from sudden turmoil and suffer from stability.

Finally, I form the FX macroeconomic momentum portfolios of economic activity, inflation and combo which's methodology is similar to Dahlquist and Hasseltoft as described in **Section 5.1** for the bond macroeconomic momentum portfolios. The excess returns are however considerably lower than Dahlquist and Hasseltoft document even as the pattern of the returns is almost identical to their findings, this can be seen in **Figure 3** which shows the cumulative excess returns of the FX macroeconomic momentum strategies. The reason for the deviation may be that I have a shorter time period as Dahlquist and Hasseltoft document a period of relatively smooth trend of positive excess returns during 1976-1989, and that I have a different sample of currencies. However, it provides a countering argument for the robust outperformance of the FX macroeconomic momentum strategy compared to FX zero-cost portfolios of carry, price momentum and value. **Table 3** reports the key

Figure 3. The cumulative excess returns of the FX macroeconomic momentum strategies.



statistics of the FX macroeconomic momentum portfolios by measure. The performance of the inflation measure is severely diminished compared to Dahlquist and Hasseltoft's reports with mean annualized excess returns of only 1.32 % compared to their result of mean annualized returns of 3.28 % and also considerably lower Sharpe ratio of 0.22 which is outperformed by the Sharpe ratio of the economic activity (EA) measure, 0.31. However, the similarities in autocorrelation, skewness and kurtosis suggest that the differences could be the result of a differing sample.

First in my analysis of the macroeconomic momentum investment strategy in the government bond market I will show descriptive statistics of the performance of both the unhedged and hedged portfolios based on the inflation, economic activity and combo measures. The portfolios are split further into excess returns that are generated by the long positions and into excess returns of the short positions. Then I will continue into analyzing the effect different-sized lookback periods have on the performance of the macroeconomic momentum portfolios in the government bond market. To analyze the similarities between similar lookbacks across the three measures I will form equal-weighted "term portfolios" from the short-term (1-12 months), medium-term (13-36 months) and long-term (37-60 months) lookbacks of the inflation, economic activity and combo measures. Then I will continue to testing the return drivers of the three macroeconomic momentum measures and different lookbacks with linear regression models using the FX macroeconomic momentum and the benchmark bond portfolios' excess returns.

6 Results

6.1 Descriptive results of the measure returns

Before moving on to the descriptive results of the measure portfolios, **Table 5** reports the frequency of long and short positions in a country's government bonds per measure. European economies as well as Japan show a slight tendency to have more often a short position in the inflation measure's portfolio, which is relatively self-evident as the inflation rates have been below the central banks' inflation targets for roughly the past decade. For the economic activity measure there's less geographical clustering in both long and short positions, as for example, Italy and France have 61.8 % and 19.8 % of the months a positive weight. Out of the G4 economies (US, EU, UK and Japan) the U.S. receives significantly more often long positions than 50/50, with having a long position in the inflation measure's portfolio 60.8 % and a long position in both the economic activity's (EA) and combo measure's portfolios 83.7 % and 63.2 % during the sample timeframe of 1/1989 – 4/2020. Also the U.K. has a significantly higher frequency of long positions across the three measures: 59.6 % within the inflation portfolio and 71.7 % and 63.7 % within the economic activity (EA) and combo portfolios, respectively. Quite surprisingly, emerging market economies such as Mexico and Hungary receive short positions more often than long positions across all measure portfolios, so there seems to be slight clustering to being short on the debt of rising economies more often than being long, and to being more often long on the sovereign debt securities of developed economies such as the G4 than being short on them.

Table 5. The frequency of long and short positions within the three measure portfolios of inflation, economic activity (EA) and combo across all lookbacks (1-60 months).

	Inflation		EA		Combo	
Country	**Long position**	**Short position**	**Long position**	**Short position**	**Long position**	**Short position**
UK	0.596	0.404	0.717	0.283	0.637	0.363
Japan	0.442	0.558	0.102	0.898	0.312	0.688
Switzerland	0.268	0.732	0.024	0.976	0.164	0.836
Canada	0.605	0.395	0.615	0.385	0.600	0.400
Australia	0.656	0.344	0.818	0.182	0.710	0.290
New Zealand	0.446	0.554	0.661	0.339	0.479	0.521
Sweden	0.533	0.467	0.543	0.457	0.508	0.492
Norway	0.437	0.563	0.689	0.311	0.489	0.511
Denmark	0.440	0.560	0.611	0.389	0.436	0.564
Germany	0.518	0.482	0.326	0.674	0.468	0.532
France	0.393	0.607	0.198	0.802	0.345	0.655
Italy	0.264	0.736	0.614	0.386	0.371	0.629
Spain	0.595	0.405	0.742	0.258	0.640	0.360
Portugal	0.428	0.572	0.557	0.443	0.455	0.545
Austria	0.491	0.509	0.558	0.442	0.509	0.491
Netherlands	0.540	0.460	0.582	0.418	0.534	0.466
Belgium	0.562	0.438	0.596	0.404	0.578	0.422
Ireland	0.762	0.238	0.560	0.440	0.771	0.229
Finland	0.570	0.430	0.416	0.584	0.546	0.454
Poland	0.555	0.445	0.329	0.671	0.513	0.487
Hungary	0.382	0.618	0.447	0.553	0.402	0.598
Czechia	0.569	0.431	0.169	0.831	0.519	0.481
South Korea	0.514	0.486	0.286	0.714	0.425	0.575
Mexico	0.366	0.634	0.479	0.521	0.419	0.581
South Africa	0.470	0.530	0.468	0.532	0.538	0.462
USA	0.608	0.392	0.837	0.163	0.632	0.368

6.1.1 Unhedged returns

Out of the unhedged macroeconomic momentum bond portfolios the inflation measure is the only one showing outperformance compared to the value-weighted bond index, which is in this case assumed to be the market portfolio. The outperformance of the inflation measure is seen in **Figure 4** and **Table 6** which show the cumulative excess returns of each macroeconomic momentum measure, as well as the value-weighted and equal-weighted bond indices, and key statistics of each measure's performance including the disaggregated statistics of the long and short positions within each measure. The inflation measure's mean annualized excess returns of 2.98 % and cumulative excess returns 151.2 % are significantly higher than the value-weighted bond index' mean annualized excess returns of 2.01 % and cumulative excess returns of 86.5 %, while the equal-weighted market index performs slightly weaker than the inflation measure with mean annualized excess returns of 2.79 % and cumulative excess returns of 136.8 %. From an investor's point-of-view the result, that a naïve and simple investment strategy performs nearly as well as a more complicated one, is encouraging as in practice a long-short bond portfolio like the macroeconomic momentum portfolios could be impractical to form due to lower short-selling supply of the bond market.

Figure 4. The cumulative excess returns of the unhedged bond macroeconomic momentum strategies.

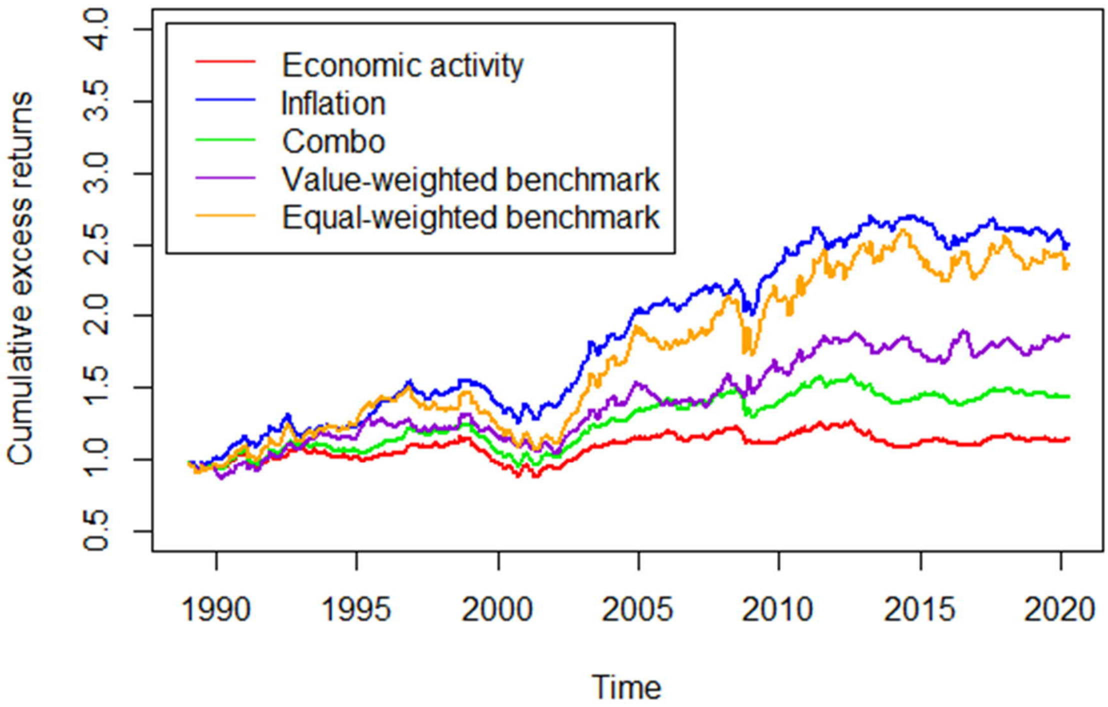


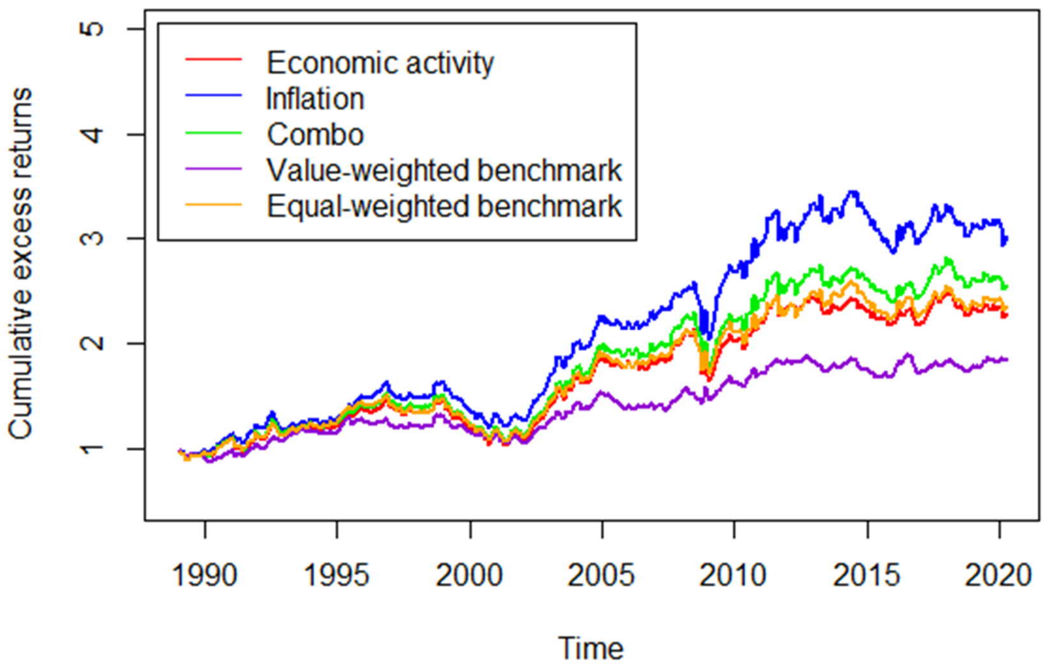
Table 6. Left panel: Annualized mean excess returns, standard deviation, and Sharpe ratio of currency-unhedged bond macroeconomic momentum returns based on monthly returns and their first-order autocorrelation, skewness and excess kurtosis. **Middle panel:** Annualized mean excess returns, standard deviation, and Sharpe ratio of the long positions of currency-unhedged bond macroeconomic momentum returns based on monthly returns and their first-order autocorrelation, skewness and excess kurtosis. **Right panel:** Annualized mean excess returns, standard deviation, and Sharpe ratio of the short positions of currency-unhedged bond macroeconomic momentum returns based on monthly returns and their first-order autocorrelation, skewness and excess kurtosis.

	Measure portfolios			Long positions			Short positions		
	Inflation	EA	Combo	Inflation	EA	Combo	Inflation	EA	Combo
Mean	2.984	0.417	1.176	3.599	2.680	3.053	-0.980	-2.713	-2.292
St. Dev.	5.847	4.623	5.181	9.219	8.685	9.021	5.134	7.027	6.391
Sharpe ratio	0.510	0.090	0.227	0.390	0.309	0.338	-0.191	-0.386	-0.359
AR(1)	0.144	0.128	0.144	0.058	0.081	0.072	-0.026	-0.018	-0.026
Skewness	0.056	0.089	-0.099	-0.226	-0.254	-0.250	0.228	0.336	0.266
Kurtosis	4.499	6.162	6.010	4.727	4.989	4.972	6.199	5.141	5.133

The other unhedged measures, economic activity (EA) and combo underperform the benchmark indices by a significant margin with mean annualized returns of 0.42 % and 1.18 %, respectively, and cumulative excess returns of 13.9 % and 44.3 %, respectively. Also, the risk-adjusted returns of these measure portfolios are weaker than the benchmark indices with Sharpe ratios of 0.09 for the economic activity measure and 0.23 for the combo measure. This finding is the first indication that these macroeconomic momentum measures possibly don't exhibit similar dynamics in the government bond market than Dahlquist and Hasseltoft (2019) find in the FX markets. Especially, the underperformance of the economic activity measure provides some initial evidence that macroeconomic momentum returns and bond carry returns could not be correlated in contrast to my hypothesis that past macroeconomic trends influence expectations of the future, which steepen the sovereign yield curve and increase bond carry returns. However, further analysis is needed to make a conclusion of the hypothesis.

The disaggregation of the measure portfolios' excess returns into the excess returns of long and short positions shows that the long positions generate the profits and the short positions mostly incur losses, as seen in **Table 6's** middle and right-side panels while **Figures 5 and 6** show the cumulative excess returns of the long and short positions, respectively. The measures' long positions generate mean annualized excess returns of 3.60 %, 2.68 % and 3.05 % for the inflation, economic activity and combo measures, respectively, which outperform the value-weighted index, while their risk-adjusted returns are in close range of the value-weighted index with Sharpe ratios of 0.39, 0.31 and 0.34. The cumulative excess returns of the measure portfolios' long positions equal to 201.5 %, 166.8 % and 130.2 % for inflation, economic activity and combo long positions respectively which all outperform the value-weighted index significantly and all but the economic activity measure's

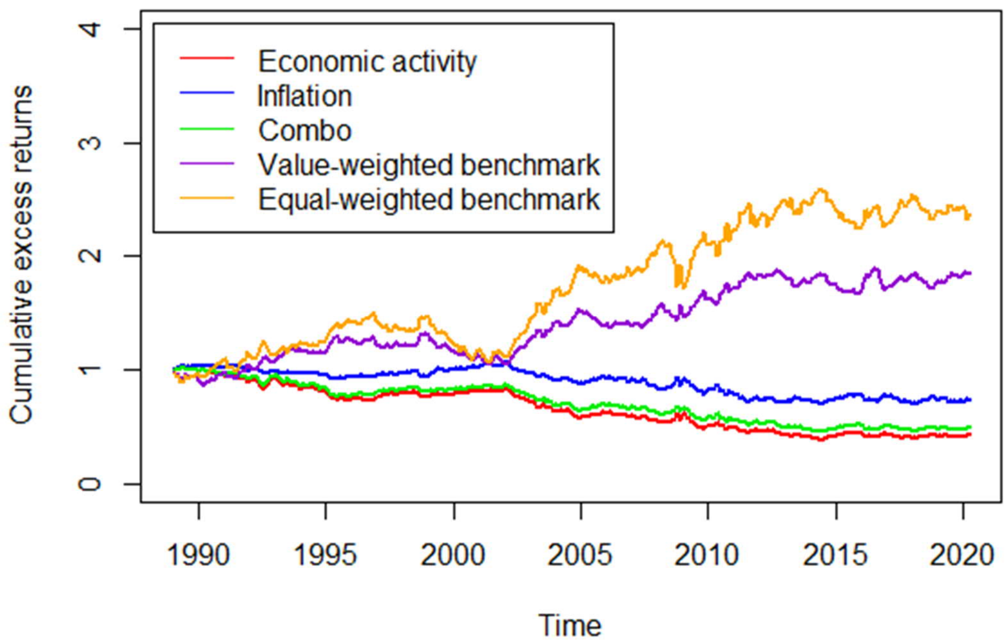
Figure 5. The cumulative excess returns of the long positions of the currency-unhedged bond macroeconomic momentum strategies.



long positions also outperform the simple equal-weighted benchmark index. The finding that the long positions across all measures significantly outperform the market serves as an argument to analyze the long and short positions separately for evidence of macroeconomic momentum in addition to the long-short portfolio, as the original framework of Dahlquist and Hasseltoft (2019) of investing in a macroeconomic momentum portfolio through a long-short portfolio could hinder the results in the bond market due to the time-decay element of fixed-income securities compared to currencies.

The short positions generate at best minimal positive excess returns throughout the sample period with mean annualized excess returns of -0.98%, -2.71 % and -2.29 % and cumulative excess returns of -18.3 %, -55.1 and -50.3 % for the inflation, economic activity and combo short positions respectively. The return volatility on these positions is significantly lower compared to the long positions and due to that they offer diversification to the long-short portfolio even as they generate losses most of the time.

Figure 6. The cumulative excess returns of the short positions of the currency-unhedged bond macroeconomic momentum strategies.



The results from the currency-unhedged portfolios indicate that the inflation measure is the most prominent to show evidence of macroeconomic momentum in the government bond market, while it is too early to give judgement on that as the FX returns of the bond portfolio need to be controlled for as the portfolio weights of the inflation measure are same for the FX and bond portfolios, of which the FX portfolio has been shown by Dahlquist and Hasseltoft (2019) to generate robust alpha in the

FX markets. To further shed light on my research questions I next move to descriptively analyzing the performance of the currency-hedged portfolios.

6.1.2 Hedged returns

The performance of the currency-hedged portfolios show that a major portion of the currency-unhedged portfolios excess returns come from FX exposure, most probably from FX macroeconomic momentum, and that the prospects of macroeconomic momentum being a sovereign bond market phenomenon in addition to being an FX market phenomenon are based on these descriptive findings l5ow. The key statistics of the currency-hedged portfolios can be seen in the left panel of **Table 7** while the cumulative excess returns are shown in **Figure 7.** All of the measure portfolios underperform the value-weighted and equal-weighted benchmark indices significantly with the inflation measure's mean annualized excess returns being reduced to 0.96 % in addition to the combo measure exhibiting near-zero excess returns of 0.02 % while the economic activity measure generates negative excess returns of -0.23 %. The cumulative excess returns generated by the measure portfolios stand at 35.1 %, -6.96 % and 0.73 % for inflation, economic activity and combo measures, respectively.

Unlike usual long-short portfolios, **Figure 7** shows some indication that the measure portfolios' performance are relatively market-sensitive during the first half of the sample period while the correlation between the market and measure portfolios diminishing significantly during the latter half of the sample period, which could be an initial indication that unlike the zero-cost portfolios that Dahlquist and Hasseltoft (2019) used to explain the macroeconomic momentum returns in the FX markets, the strategy could potentially be market-sensitive in general. While the FX market does not have a clear market benchmark similar to equity or bond markets, testing the strategy returns in the bond market and with a market benchmark could potentially give further arguments to continue researching the macroeconomic momentum effect in the FX markets as well as in other asset classes.

The disaggregation into excess returns generated by the long and short positions of the measures shows similar results to the findings with the currency-unhedged portfolios as the long positions generate positive excess returns and the short positions generate negative excess returns, which however are milder than the losses generated by the currency-unhedged short positions. **Figures 8 and 9** show the cumulative performance of the long and short positions while the middle and right panels of **Table 7** show the key statistics of the long and short sub-portfolios of each measure. The long positions seem to be significantly correlated with the market as can be seen in

Figure 8 while the short positions show a weakly negative correlation with the market index as can be seen in **Figure 9**. Unlike the currency-unhedged portfolio returns, the currency-hedged portfolio returns underperform across all measures, even the initially-prominent inflation measure, with the mean annualized excess returns of the measures' long positions lagging the benchmark market indices with 2.40 %, 2.12 % and 2.15 % for inflation, economic activity and combo long positions, respectively, while the Sharpe ratios of the sub-portfolios are little less than those of the benchmark market indices.

Figure 7. The cumulative excess returns of the hedged bond macroeconomic momentum strategies

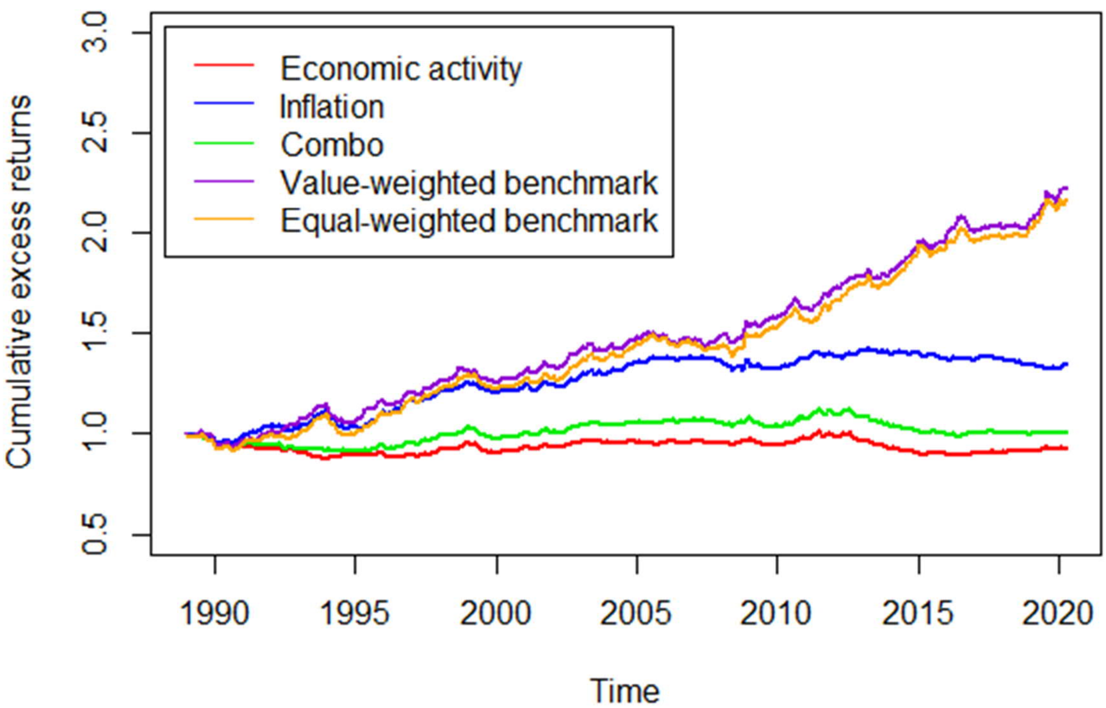


Table 7. Left panel: Annualized mean excess returns, standard deviation, and Sharpe ratio of currency-hedged bond macroeconomic momentum returns based on monthly returns and their first-order autocorrelation, skewness and excess kurtosis. **Middle panel:** Annualized mean excess returns, standard deviation, and Sharpe ratio of the long positions of currency-hedged bond macroeconomic momentum returns based on monthly returns and their first-order autocorrelation, skewness and excess kurtosis. **Right panel:** Annualized mean excess returns, standard deviation, and Sharpe ratio of the short positions of currency-hedged bond macroeconomic momentum returns based on monthly returns and their first-order autocorrelation, skewness and excess kurtosis.

	Measure portfolios			Long positions			Short positions		
	Inflation	EA	Combo	Inflation	EA	Combo	Inflation	EA	Combo
Mean	0.964	-0.230	0.023	2.400	2.115	2.151	-1.451	-2.364	-2.147
St. Dev.	2.352	1.937	2.073	3.230	2.971	3.096	2.039	2.813	2.666
Sharpe ratio	0.410	-0.119	0.011	0.743	0.712	0.695	-0.712	-0.841	-0.805
AR(1)	0.172	0.095	0.101	0.175	0.164	0.171	0.136	0.156	0.147
Skewness	0.043	-0.001	-0.091	0.100	-0.053	-0.033	-0.325	-0.136	-0.160
Kurtosis	3.507	4.344	3.571	3.697	3.076	3.161	5.925	5.909	6.234

Figure 8. The cumulative excess returns of the long positions of the currency-hedged bond macroeconomic momentum strategies.

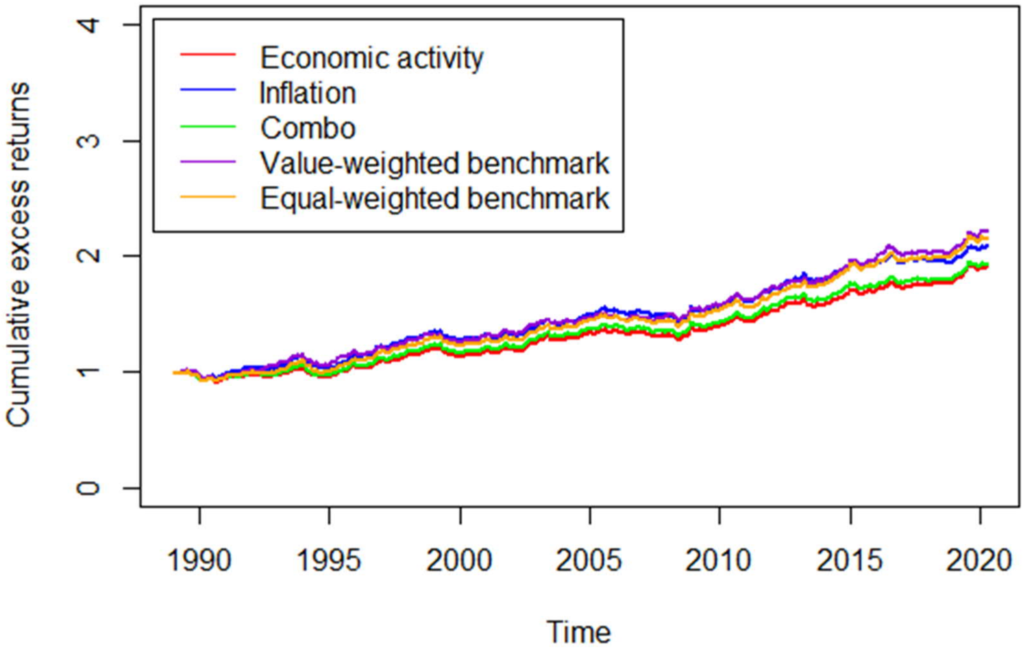
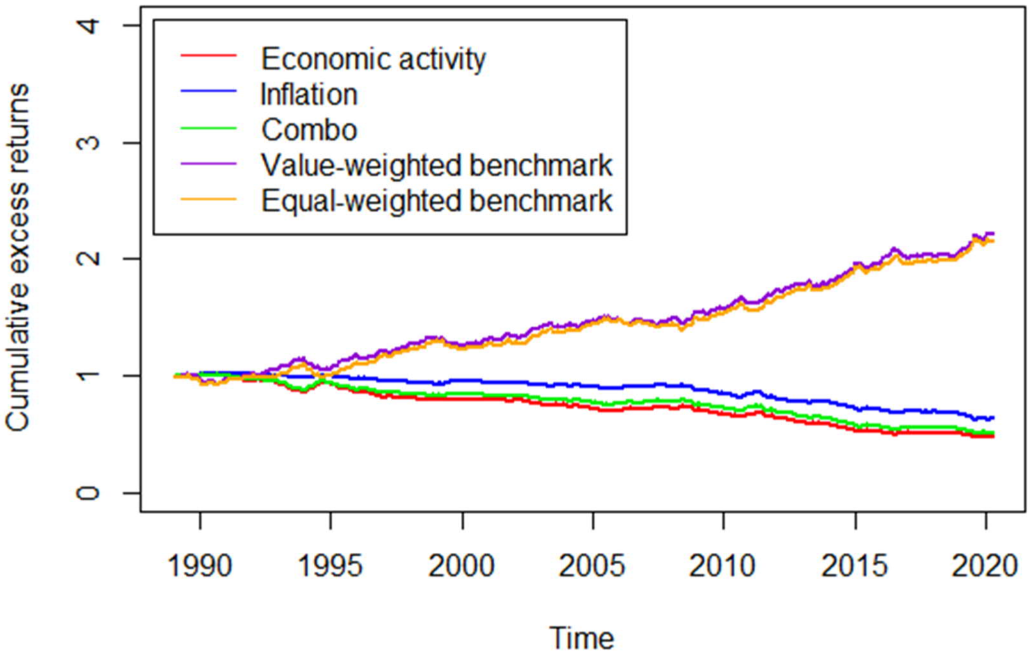


Figure 9. The cumulative excess returns of the short positions of the currency-hedged bond macroeconomic momentum strategies.



6.2 Descriptive results of the returns of different lookback periods

6.2.1 Unhedged returns

Lookback-sorted term portfolios show a similar dynamic than found by Dahlquist and Hasseltoft (2019) in the FX markets with mostly better performance in mean annualized excess returns and risk-adjusted returns among the longer lookbacks compared to shorter lookbacks across all measures. **Figure 10** reports the cumulative excess returns of each term portfolio constructed equally-weighted within each measure portfolio and lookback "basket" as well as of aggregated term portfolios that is equally-weighted among measures measures. To clarify, the aggregated short-term portfolio has weights of 33.3 % in each three of the short-term portfolios of macroeconomic momentum measures of inflation, economic activity and combo.

Figure 10. The cumulative excess returns of lookback-sorted and currency-unhedged term portfolios. Lookback sort: 1-12 months = short-term (ST), 13-36 months = medium-term (MT), 37-60 months = long-term (LT), all the term portfolios are equally-weighted among lookback portfolios. **Top left:** Aggregated term portfolios, equal-weighted between the term portfolios of different measures. **Top right:** Term portfolios of the inflation measure. **Bottom left:** Term portfolios of the economic activity (EA) measure. **Bottom right:** Term portfolios of the combo measure.

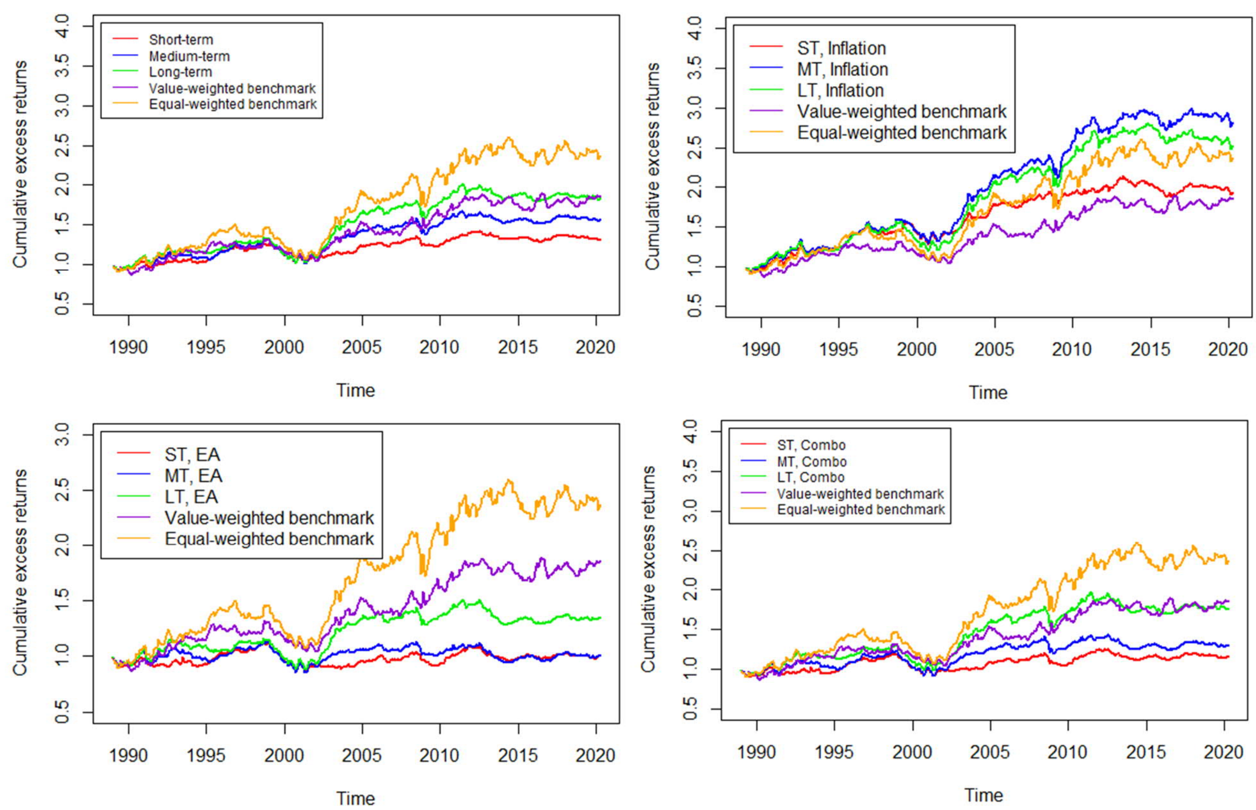


Table 8 reports the key statistics of each measure's term portfolios and of the aggregated term portfolios. The inflation measure's term portfolios show different kind of dynamics compared to combo and economic activity measures' term portfolios, as the medium-term portfolio outperforms the long-term portfolio by a slight margin with mean annualized excess returns of 3.37 % vs. 3.00 %,

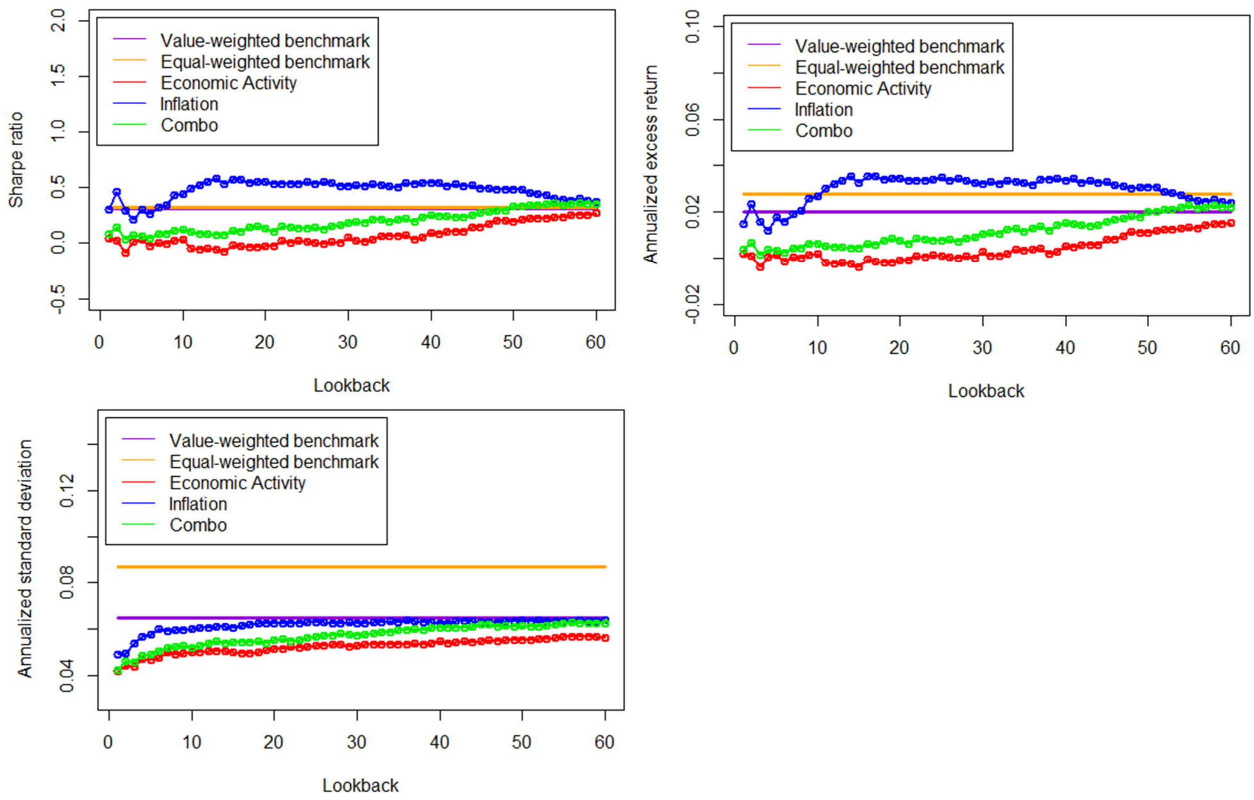
and even the short-term portfolio of the inflation measure outperforms the short-term portfolios of economic activity and combo measures' short-term portfolios by a large margin with mean annualized excess returns of 2.13 % vs. 0.01 % and 0.46 % of the economic activity and combo measures' short-term portfolios. The inflation measure is also the only one that's medium- and long-term -portfolios outperform the market index. The aggregated term portfolios show more linear differences between the term portfolios and its long-term portfolio performs on par with the market index in both mean cumulative excess returns and Sharpe ratio (85.1 % vs. 86.5 % and 0.30 vs. 0.32 for the long-term portfolio and the value-weighted market index, respectively), while due to the higher excess kurtosis of the long-term portfolio its mean annualized excess returns slightly lag those of the market index (1.63 % vs. 2.01%).

Table 8. Annualized mean excess returns, standard deviation, and Sharpe ratio of currency-unhedged bond macroeconomic momentum term portfolios based on monthly returns and their first-order autocorrelation, skewness and excess kurtosis. Lookback sort: 1-12 months = short-term (ST), 13-36 months = medium-term (MT), 37-60 months = long-term (LT), all the term portfolios are equally-weighted among lookback portfolios. **(From left to right) 1st panel:** Aggregated term portfolios. **2nd panel:** Term portfolios of the inflation measure. **3rd panel:** Term portfolios of the economic activity (EA) measure. **4th panel:** Term portfolios of the combo measure.

	Term portfolios			Inflation			EA			Combo		
	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long
Mean	0.897	1.440	1.625	2.132	3.365	3.002	0.005	0.033	0.959	0.462	0.849	1.819
St. Dev.	3.939	4.916	5.490	5.294	6.120	6.286	4.301	4.995	5.420	4.553	5.470	6.053
Sharpe ratio	0.228	0.293	0.296	0.403	0.550	0.478	0.001	0.007	0.177	0.101	0.155	0.300
AR(1)	-0.023	0.167	0.143	0.085	0.154	0.151	0.123	0.135	0.108	0.145	0.150	0.120
Skewness	0.118	0.084	0.124	0.183	0.094	-0.064	0.252	0.116	0.183	0.070	-0.105	0.067
Kurtosis	7.266	6.562	5.375	4.819	4.440	4.595	5.288	5.865	5.306	5.923	6.121	4.917

Figure 11 shows the mean annualized excess returns, standard deviation and risk-adjusted returns of different measure portfolios across all lookbacks. The dynamics of all measures across lookbacks is very similar to Dahlquist and Hasseltoft (2019) findings in the FX markets. The measures show relatively stable mean annualized excess returns, simple standard deviation of returns and Sharpe ratios across lookbacks with a slightly increasing performance in mean annualized excess returns of the economic activity and combo measures when the lookback periods are stretched longer, and the combo measure's sub-portfolios of lookbacks between 50-60 months outperform the value-weighted market index slightly in mean annualized excess returns and risk-adjusted returns. The inflation measure however outperforms the value-weighted index in those performance meters almost across all lookbacks while it achieves its highest mean annualized excess returns and risk-adjusted returns with already a 14-month lookback and shows a slight decrease after that with longer lookbacks in those performance meters. The return uncertainty increases logarithmically with longer lookbacks across all measures while the standard deviations of all measures converge to the standard deviation of the value-weighted index.

Figure 11. The mean annualized excess returns, standard deviation and Sharpe ratio of measure returns per lookback. Top left: Annualized Sharpe ratio. **Top right:** Mean annualized excess returns. **Bottom:** Annualized simple standard deviation of returns.



The fact that longer lookbacks outperform shorter lookbacks across performance meters is in line with the hypothesis that the macroeconomic momentum measure does not capture mean reversion of interest rates. However, the return patterns of the term portfolios are very familiar with the findings of Dahlquist and Hasseltoft (2019) in the FX markets so an analysis of the currency-hedged term portfolios is needed next.

6.2.2 Hedged returns

Figure 12 reports the cumulative excess returns of each term portfolio constructed equally-weighted within each measure portfolio and **Table 9** reports the key statistics of each measure's term portfolios and of the aggregated term portfolios. **Figure 13** shows the mean annualized excess returns, standard deviation and risk-adjusted returns of different measure portfolios across all lookbacks. The main similarities between the returns of currency-hedged and currency-unhedged term portfolios are that the short-term portfolios generally underperform the medium-term and long-term portfolios with the exception of the economic activity term portfolios where the short-term portfolio performs on par with the long-term portfolio, however their mean annualized excess returns are negative. Also, the inflation measure's term portfolios perform relatively as well as its currency-unhedged term portfolios in risk-adjusted returns while keeping a similar shape in the graph where Sharpe ratios are presented by lookback.

Figure 12. The cumulative excess returns of lookback-sorted and currency-hedged term portfolios. Lookback sort: 1-12 months = short-term (ST), 13-36 months = medium-term (MT), 37-60 months = long-term (LT), all the term portfolios are equally-weighted among lookback portfolios. **Top left:** Aggregated term portfolios, equal-weighted between the term portfolios of different measures. **Top right:** Term portfolios of the inflation measure. **Bottom left:** Term portfolios of the economic activity (EA) measure. **Bottom right:** Term portfolios of the combo measure.

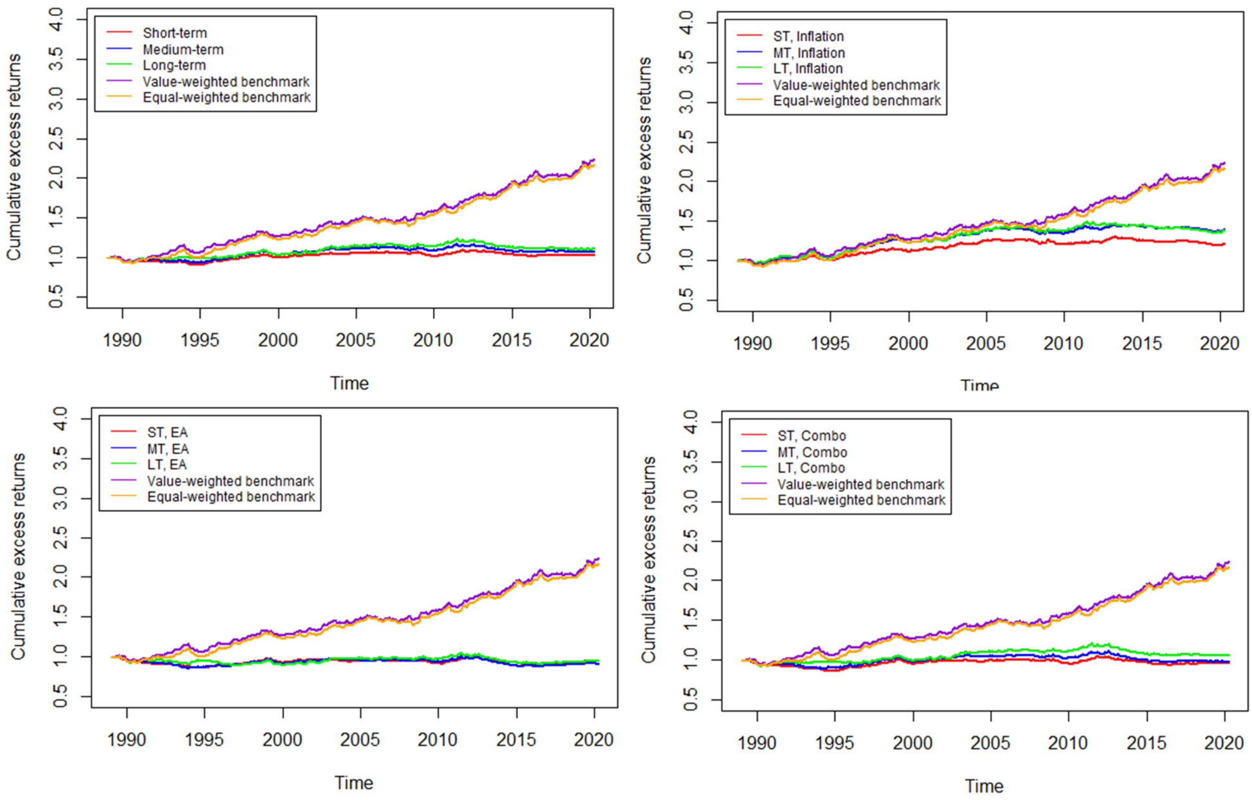
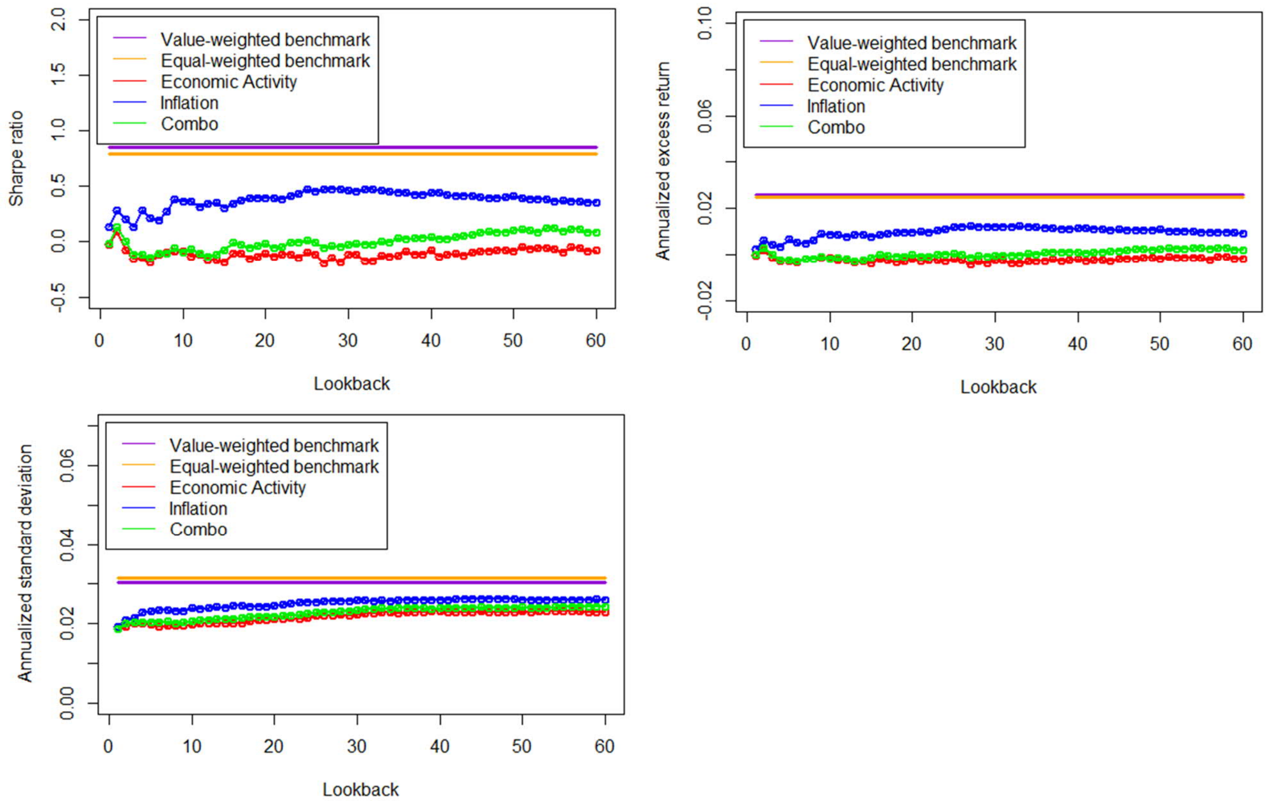


Table 9. Annualized mean excess returns, standard deviation, and Sharpe ratio of currency-hedged bond macroeconomic momentum term portfolios based on monthly returns and their first-order autocorrelation, skewness and excess kurtosis. Lookback sort: 1-12 months = short-term (ST), 13-36 months = medium-term (MT), 37-60 months = long-term (LT), all the term portfolios are equally-weighted among lookback portfolios. **(From left to right) 1st panel:** Aggregated term portfolios. **2nd panel:** Term portfolios of the inflation measure. **3rd panel:** Term portfolios of the economic activity (EA) measure. **4th panel:** Term portfolios of the combo measure.

	Term portfolios			Inflation			EA			Combo		
	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long	Short	Medium	Long
Mean	0.103	0.238	0.164	0.605	1.064	1.038	-0.244	-0.378	-0.276	-0.129	-0.068	0.185
St. Dev.	1.548	1.922	2.120	2.071	2.457	2.580	1.756	2.088	2.263	1.824	2.193	2.363
Sharpe ratio	0.067	0.124	0.077	0.292	0.433	0.402	-0.139	-0.181	-0.122	-0.071	-0.031	0.078
AR(1)	-0.118	0.129	0.106	0.169	0.167	0.161	0.116	0.102	0.090	0.129	0.111	0.085
Skewness	-0.149	-0.121	-0.103	0.072	0.036	-0.002	0.156	-0.058	0.125	0.019	-0.084	-0.093
Kurtosis	3.605	3.406	3.691	3.903	3.510	3.341	3.573	4.002	4.525	3.332	3.472	3.846

Figure 13. The mean annualized excess returns, standard deviation and Sharpe ratio of measure returns per lookback. Top left: Annualized Sharpe ratio. **Top right:** Mean annualized excess returns. **Bottom:** Annualized simple standard deviation of returns.



The list of main differences between the currency-unhedged and currency-hedged term portfolios is longer than the list of similarities as all the term portfolios underperform the market index by a large margin, the economic activity measure's term portfolios perform slightly weaker with longer lookbacks and the aggregated medium-term portfolio outperforms the long-term aggregated portfolio. These differences are however rather small when considering the previous findings about the currency-hedged returns' underperformance across all measures in **Section 6.1.2** and my hypothesis of carry returns driving the returns during sustained market and economic stability with steeper yield curves result in better performance with longer lookbacks across all measures stands for now.

6.3 Return drivers of the currency-unhedged measure and term returns

In this chapter I will use linear regression models to study the return drivers of the macroeconomic momentum bond portfolios. In total, I will have 12 dependent variables (excess returns of three measure portfolios and three aggregated term portfolios, both currency-hedged and currency-unhedged returns) and six independent variables: excess returns of currency-hedged bond carry, bond price momentum, bond value and bond market portfolios and for the currency-unhedged macroeconomic momentum portfolios also the excess returns of the corresponding FX macroeconomic momentum portfolio and the ICE U.S. dollar DXY index. All the regressions use Newey-West standard errors that account for heteroscedasticity and serial correlation with up to 3 lags, similar robust standard errors are used by Dahlquist and Hasseltoft (2019). I choose to use currency-hedged bond factor portfolios as independent variables also when using the currency-unhedged macroeconomic momentum portfolios as dependent variables due to potential issues with multicollinearity as the FX macroeconomic momentum returns correlate significantly with the currency-unhedged bond factor portfolio returns. Inclusion of the currency-unhedged bond portfolio returns would add to the slight multicollinearity issues with the correlation between the bond factor portfolios which I check for each regression using the variance inflation statistic. As the exclusion of the bond factor portfolios' FX returns potentially inflates the alpha and coefficients of the included independent variables and reduces the fit of the model, I will need to base my overall findings on the regression results of both the currency-unhedged and the currency-hedged macroeconomic momentum portfolio returns. Even as this method reduces the importance of the regression results with the currency-unhedged macroeconomic momentum portfolio returns, they will also offer meaningful insight as the currency-unhedged inflation measure portfolio drastically outperforms the market index. Also, by using the excess returns of currency-hedged bond factor portfolios in regressing the excess returns of both currency-unhedged and currency-hedged macroeconomic momentum portfolios still distinguishes return drivers of bond market factors.

Table 10. Correlation matrix of the currency-unhedged variables. Upper triangle shows the Pearson correlation coefficients and the lower triangle the p-value of the coefficients according to the Student t-test. From left to right: **1st panel:** Excess returns of currency-unhedged bond macroeconomic momentum portfolios (economic activity, inflation, combo and aggregated term portfolios) **2nd panel:** Excess returns of currency-hedged bond benchmark portfolios (carry, price momentum, value and value-weighted market index) **3rd panel:** Excess returns of FX benchmark portfolios (economic activity, inflation and combo FX macroeconomic momentum portfolios, as well as their aggregated term portfolios, and the ICE U.S. Dollar Index's USD based returns)

		Bond macroeconomic momentum, dependent variables						Bond independent variables				FX independent variables						
		EA	Inflation	Combo	Short	Med	Long	Carry	Momentum	Value	Market	EA	Inflation	Combo	Short	Med	Long	DXY
Bond macroeconomic momentum, dependent variables	EA		0.54	0.95	0.81	0.91	0.83	-0.05	0.12	-0.16	0.27	0.50	-0.02	0.21	0.35	0.40	0.26	0.36
	Inflation	(0.00)		0.75	0.69	0.82	0.88	0.26	-0.01	0.05	0.22	0.10	0.17	-0.04	0.25	0.32	0.32	0.65
	Combo	(0.00)	(0.00)		0.85	0.98	0.93	0.07	0.08	-0.10	0.27	0.45	0.08	0.20	0.37	0.42	0.32	0.49
	Short-term	(0.00)	(0.00)	(0.00)		0.86	0.72	0.07	0.04	-0.10	0.25	0.30	0.01	0.08	0.42	0.33	0.19	0.44
	Med-term	(0.00)	(0.00)	(0.00)	(0.00)		0.93	0.09	0.07	-0.09	0.27	0.39	0.09	0.14	0.38	0.45	0.32	0.52
	Long-term	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		0.14	0.06	-0.04	0.26	0.34	0.12	0.11	0.27	0.38	0.36	0.60
Bond independent variables	Carry	(0.34)	(0.00)	(0.16)	(0.16)	(0.08)	(0.00)		-0.22	0.25	-0.13	-0.05	0.30	0.15	0.05	0.01	0.08	0.15
	Momentum	(0.02)	(0.84)	(0.12)	(0.43)	(0.18)	(0.23)	(0.00)		-0.51	0.13	0.10	-0.14	-0.04	-0.02	0.08	0.04	-0.05
	Value	(0.00)	(0.37)	(0.04)	(0.06)	(0.10)	(0.43)	(0.00)	(0.00)		-0.07	-0.15	0.14	0.00	-0.08	-0.08	-0.01	0.13
	Market	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.17)		0.14	-0.13	0.00	0.01	-0.01	-0.07	0.04
FX independent variables	EA	(0.00)	(0.06)	(0.00)	(0.00)	(0.00)	(0.00)	(0.31)	(0.04)	(0.00)	(0.00)		0.10	0.63	0.45	0.54	0.44	0.04
	Inflation	(0.69)	(0.00)	(0.13)	(0.86)	(0.09)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	(0.06)		0.73	0.27	0.39	0.47	-0.22
	Combo	(0.00)	(0.46)	(0.00)	(0.11)	(0.00)	(0.03)	(0.00)	(0.39)	(0.99)	(0.98)	(0.00)	(0.00)		0.37	0.48	0.47	-0.26
	Short-term	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.34)	(0.75)	(0.13)	(0.78)	(0.00)	(0.00)	(0.00)		0.78	0.59	0.04
	Med-term	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.77)	(0.13)	(0.12)	(0.79)	(0.00)	(0.00)	(0.00)	(0.00)		0.87	0.03
	Long-term	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.49)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		0.02
	DXY	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.30)	(0.00)	(0.44)	(0.40)	(0.00)	(0.00)	(0.47)	(0.51)	(0.69)	

The correlation matrix for the variables used in the regressions of currency-unhedged macroeconomic momentum returns can be seen in **Table 10.** The correlation matrix shows that the returns of the currency-unhedged bond macroeconomic momentum measure portfolios correlate with the currency-hedged value-weighted market index with statistically significant Pearson correlation coefficients within a tight range of 0.22 to 0.27. The excess returns of the aggregated bond term portfolios also correlate with the market index in a narrow range of 0.25 to 0.27 highlighting that the macroeconomic momentum strategy is not market-neutral in the government bond market. This is slightly contradicting to the strategy's dynamics in the FX market where the strategy mostly shows market-neutrality with the economic activity measure portfolio's and the aggregated term portfolios' excess returns having near-zero correlation with the excess returns of the DXY index. The positive market correlation coefficients of the excess returns of government bond macroeconomic momentum portfolios potentially stem from the correlation of sovereign yields with the global factor as documented by Diebold et al (2007) and Driessen et al (2000) This also potentially underlines the importance of having a market factor in the independent variables when testing macroeconomic momentum excess returns in addition to zero-cost factor portfolio excess returns as the bond macroeconomic momentum portfolios are clearly not market-neutral unlike long-short portfolios typically should be.

The excess returns of the bond macroeconomic momentum portfolios correlate statistically significantly and positively with the excess returns of the corresponding FX macroeconomic momentum portfolios. However, the correlation coefficient of the bond economic activity measure and the FX macroeconomic momentum measure is significantly higher (0.50) than the correlation coefficients of the inflation and combo measures (0.17 and 0.20 respectively). The aggregated bond term portfolios have statistically significant and positive correlation coefficients with their respective FX portfolios, ranging from 0.36 to 0.45 while showing no increasing or decreasing trends with longer lookbacks. This highlights how sensitive the strategy's currency-unhedged returns in the government bond market are to FX market movements, while the correlation coefficients with the currency-hedged zero-cost bond portfolios remain relatively low.

The currency-hedged carry portfolio's excess returns correlate especially significantly with the currency-unhedged inflation measure's excess returns (coefficient is 0.26) which shows initial evidence for my hypothesis of the carry factor being a driver of the returns of the macroeconomic momentum strategy. This is finding is however relatively limited to the inflation measure as the correlation coefficients of the carry factor and the economic activity measure, combo measure, aggregated short-term and aggregated medium-term portfolios are statistically insignificant with the aggregated long-term portfolio having the only statistically significant and positive correlation coefficient (0.14) in addition to the inflation measure portfolio. There's a slight indication that the correlation of the carry portfolio and the macroeconomic momentum portfolios has an increasing trend with longer lookbacks, but that should be further investigated with the currency-hedged bond macroeconomic momentum returns later.

The currency-hedged price momentum portfolio shows mostly statistically insignificant correlation with the bond macroeconomic momentum portfolios except for the economic activity measure portfolio, which is contradicting to the findings of Dahlquist and Hasseltoft (2019) that excess returns of price momentum correlate positively and statistically significantly with the macroeconomic momentum strategy's measure portfolios in the FX market. The currency-hedged value factor shows some statistical significance and relatively robustly negative correlation coefficients with the macroeconomic momentum portfolios. That is some evidence for my hypothesis that the macroeconomic momentum strategy has a structural short position for trend reversals in macroeconomic indicators. However, the relations of the zero-cost portfolios need to be studied more closely with the currency-hedged macroeconomic momentum portfolios to conclude on the effect of the bond market factors.

6.3.1 Measure returns

The results from the linear regressions, where the dependent variables are the currency-unhedged measure portfolios, are reported in **Table 11, Panel 1** reports the results for the inflation measure portfolio, **Panel 2** for the economic activity measure portfolio and **Panel 3** for the combo measure portfolio. The market index is statistically significant throughout regression models and measure portfolios at the 0.01 % level, which indicates that the strategy indeed is not market-neutral in the government bond market, and is supported by evidence from Diebold et al (2007) and Driessen et al (2000) that sovereign yields, and therefore global government bond market returns are affected by global factor. Also, the macroeconomic momentum strategy does not achieve market-neutrality like long-short portfolios aim to achieve. The strongest dependency from the market factor can be seen inflation and combo measure portfolios with the market factor receiving factor loadings ranging from 0.417 to 0.468 and from 0.403 to 0.467 respectively. Even as the market factor receives a very similar loading with the economic activity measure portfolio as the dependent variable in a single-factor model compared to the inflation and combo measure portfolios (0.410), models with additional

Table 11. Regression results for the unhedged measure excess returns, factor estimates and t-values are reported (in brackets). The dependent variables used in the regressions are excess returns from the value-weighted market index, excess returns of the measure-corresponding macroeconomic momentum strategy in FX (FX MM), and excess returns from government bond carry, price momentum and value strategies. All regressions use Newey-West standard errors that account for conditional heteroscedasticity and serial correlation with up to 3 lags. Alpha is annualized.

Unhedged returns

Pane 1: Inflation measure

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Alpha	2.023	2.864	4.596	2.341	3.133	3.083	2.207	2.743	2.969	3.135	2.748
	(1.776 .)	(2.48 *)	(4.986 ***)	(1.954 .)	(2.648 **)	(2.666 **)	(1.857 .)	(3.488 ***)	(3.731 ***)	(3.998 ***)	(3.488 ***)
Bond index	0.417							0.468	0.443	0.444	0.458
	(3.478 ***)							(5.747 ***)	(5.686 ***)	(5.686 ***)	(5.821 ***)
FX MM		0.168						0.326	0.36	0.369	0.338
		(1.907 .)						(8.479 ***)	(10.063 ***	10.031 ***	(8.845 ***)
DXY			0.466					0.502	0.518	0.526	0.511
			(11.667 ***					(13.23 ***)	(13.9 ***)	13.704 ***	13.522 ***
Carry				0.644			0.669	0.212			0.268
				(4.779 ***)			(4.906 ***)	(1.884 .)			(2.789 **)
Momentum					-0.02		0.103		0.1		0.036
					(-0.135)		(0.715)		(1.286)		(0.483)
Value						0.09	0.013			-0.175	-0.193
						(0.73)	(0.115)			(-2.2 *)	(-2.469 *)
Adj. R-squared	0.044	0.026	0.426	0.063	-0.003	-0.001	0.060	0.586	0.582	0.587	0.595
n	376	376	376	376	376	376	376	376	376	376	376

Pane 2: Economic activity measure

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Alpha	-0.551	-0.247	1.169	0.639	0.34	0.607	0.526	-0.189	-0.41	-0.202	-0.131
	(-0.61)	(-0.303)	(1.394)	(0.651)	(0.365)	(0.646)	(0.538)	(-0.255)	(-0.597)	(-0.295)	(-0.179)
Bond index	0.41							0.284	0.282	0.283	0.278
	(5.003 ***)							(3.571 ***)	(3.668 ***)	(3.657 ***)	(3.551 ***)
FX MM		0.631						0.577	0.572	0.556	0.556
		(8.148 ***)						(8.268 ***)	(8.041 ***)	(7.882 ***)	(7.841 ***)
DXY			0.204					0.192	0.19	0.198	0.199
			(3.948 ***)					(4.517 ***)	(4.485 ***)	(4.604 ***)	(4.649 ***)
Carry				-0.097			-0.01	-0.103			-0.05
				(-0.763)			(-0.076)	(-0.936)			(-0.5)
Momentum					0.189		0.08		0.105		0.004
					(1.914 .)		(0.773)		(1.185)		(0.054)
Value						-0.245	-0.203			-0.193	-0.182
						(-2.538 *)	(-1.723 .)			(-2.039 *)	(-1.892 .)
Adj. R-squared	0.070	0.253	0.128	0.000	0.012	0.023	0.020	0.402	0.404	0.415	0.412
n	376	376	376	376	376	376	376	376	376	376	376

Pane 3: Combo measure

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Alpha	0.081	1.014	2.296	1.112	1.165	1.365	0.985	0.954	0.726	1.025	0.985
	(0.079)	(0.937)	(2.568 *)	(0.987)	(1.111)	(1.286)	(0.886)	(1.122)	(0.905)	(1.295)	(1.178)
Bond index	0.467							0.419	0.405	0.405	0.403
	(4.912 ***)							(4.861 ***)	(5.023 ***)	(4.919 ***)	(4.817 ***)
FX MM		0.203						0.363	0.362	0.362	0.362
		(1.924 .)						(6.187 ***)	(6.615 ***)	(6.519 ***)	(6.413 ***)
DXY			0.312					0.367	0.366	0.377	0.377
			(5.728 ***)					(7.821 ***)	(8.026 ***)	(8.413 ***)	(8.246 ***)
Carry				0.16			0.243	-0.082			0.007
				(1.093)			(1.68 .)	(-0.572)			(0.054)
Momentum					0.143		0.091		0.172		0.032
					(1.173)		(0.73)		(1.713 .)		(0.355)
Value						-0.178	-0.179			-0.286	-0.271
						(-1.824 .)	(-1.488)			(-3.116 **)	(-2.851 **)
Adj. R-squared	0.072	0.036	0.242	0.003	0.004	0.008	0.015	0.414	0.422	0.440	0.437
n	376	376	376	376	376	376	376	376	376	376	376

variables compress the coefficient to range between 0.278 and 0.284. This difference with the economic activity measure can be explained by the significantly higher loading for the FX macroeconomic momentum portfolio returns: the single-factor models using the corresponding FX macroeconomic momentum measure portfolio returns as the independent variable generate factor loadings of 0.168 for the inflation measure portfolio and 0.203 for the combo measure portfolio, while the loading inflates to 0.631 for the economic activity measure portfolio.

In general, the currency-unhedged macroeconomic momentum returns are heavily driven by the FX factors while the bond carry, bond price momentum and bond value factor returns receive mostly relatively small coefficients. Even if the models included the FX returns of the currency-unhedged bond factor portfolios it is evident that most of the performance of the currency-unhedged macroeconomic momentum measure portfolios stems from taking FX risk. Especially the economic activity measure portfolio's returns are vastly driven by FX factors with only the bond market factor having a robust statistically significant coefficient out of the bond factor variables. Looking at the model fits based on the adjusted R-squared statistic, it can be shown that bond factors explain very little variance compared to the FX factors: the single-factor models produce constantly adjusted R-squared values less than 0.10 for the bond factors while the FX factors receive much higher values. The excess returns of the DXY index receive an adjusted R-squared of 0.426, 0.128 and 0.242 respectively for the inflation, economic activity and combo measure portfolios in a single-factor setting while the FX macroeconomic momentum measure portfolio excess returns receive values of 0.026, 0.253 and 0.036, respectively. However, it is noteworthy that the excess returns of the DXY index receives higher adjusted R-squared and coefficient values compared to the FX macroeconomic momentum measure portfolios in the case of the inflation and combo measure portfolios: this could indicate that the findings of Dahlquist and Hasseltoft (2019) could be impacted by accounting for the FX market factor and that the macroeconomic momentum strategy is more market-sensitive than initially documented by them.

Out of the bond factor portfolios the carry and value factors show some significance in line with my hypotheses. However, the carry factor receives a robust, positive and statistically significant coefficient only with the inflation measure portfolio (0.644 in a single-factor setting, 0.268 in the full model) while the value factor shows a somewhat robust and negative coefficient across the three measure portfolios in a full model setting. This indicates that especially the inflation measure strategy allocates based on the steepness of a country's sovereign yield curve, being long in countries' sovereign debt with steeper curves and short in country's sovereign debt with flatter curves. Because the carry factor does not receive a significant loading with other macroeconomic momentum measure portfolios the reason for the inflation measure's high carry loading could be the result of an inflation-specific phenomenon that steepens sovereign yield curves. From the perspective of the expectations theory this could be translated into the market's higher expectations of the short-term interest rate for country's with higher past inflation rates. This can be argued to be inflation-specific on a global level, as most central banks in my sample have a single mandate to control inflation, with the exception of the Federal Reserve which has a dual mandate to also support employment. However as Ilmanen and Iwanowski (1997) have shown, the market is poor in predicting future short-term rates and that the expectations theory has limited empirical evidence to support it, the liquidity preference theory could on the other hand suggest that past inflation translates into expected inflation rates and inflation risk premium which steepen sovereign yield curves. This is supported by Fisher (1925 and 1930) and Andersen et al (2003) who shows that past inflation affects positively inflation expectations and also by the fact that the inflation measure portfolio's performance has been relatively poor since the Great Financial Crisis which flattened yield curves especially in the eurozone persistently due to low inflationary pressures and expectations. As Christensen et al (2010) show that inflation risk premia have also been decreasing during the past decades to near-zero levels the inflation measure portfolio's high carry loading and past poor performance could be attributed to inflation expectations and inflation risk premia.

The value factor's negative coefficients across measure portfolios is in line with my hypothesis of the macroeconomic momentum strategy being structurally short on trend reversals in macroeconomic indicators. As the macroeconomic momentum strategy takes long positions in government bonds of countries with positive past macroeconomic trends and short positions in government bonds of countries with negative past macroeconomic trends, the countries where the strategy takes long positions should theoretically experience further increases in sovereign yields and the short positions' countries further decreases in sovereign yields. Both the expectations theory and liquidity preference theory back this, as positive/negative macroeconomic conditions translate into increases/decreases in expectations of short-term interest rates and inflation rates. Of course, negative macroeconomic trends can also incur increases in sovereign yields if the country is e.g. near default which would increase its sovereign risk premia. The price momentum factor receives near-zero coefficients across all measures and shows the macroeconomic momentum strategy shows different dynamics in the government bond market than in the FX markets.

The linear models show that the inflation measure portfolio could generate a robust and statistically significant alpha even when controlled for a significant portion of FX risk, similar to Dahlquist and Hasseltoft (2019) findings in the FX markets. The alpha is relatively high at about 3 % excess returns annually: the full model shows an annualized alpha of 2.748 %. However, the model fit remains relatively low at 0.595 with the full model and the exclusion of the bond factor portfolios' FX returns potentially inflates the alpha.

6.3.2 Term returns

The linear regression test setup remains the same as in **Section 6.3.1** with the measure returns: the dependent variables are the excess returns of the short-term, medium-term and long-term portfolios that are aggregated from the measure portfolios, i.e. the short-term portfolio consists of inflation, economic activity and combo measure sub-strategies which have lookbacks less than or equal to 12 months, the medium-term portfolio consists of lookbacks of 13-36 months and the long-term portfolio of lookbacks of 37-60 months. All sub-strategies are equally-weighted within each 'term portfolio' and the excess returns of these term portfolios are fitted into 11 different model setups where the independent variables are similar to the independent variables used in **Section 6.3.1**: excess returns of the hedged bond factor portfolios, DXY index and the FX macroeconomic momentum term portfolios, which are formed similar to the bond macroeconomic momentum term portfolios. The regressions use Newey-West standard errors with 3 lags and statistically significant multicollinearity is controlled for with variance inflation. The regression results are reported in **Table 12.**

The market factor receives positive and statistically significant, at the 0.01 % level, coefficient estimates across the term portfolios with a slight increase when moving from shorter lookbacks to longer lookbacks: the loading increases substantially in the medium-term portfolio regression to 0.444 from the short-term portfolio regression's 0.322 in the single-factor model and increases slightly again in the long-term portfolio single-factor model to 0.474. The market factor loadings remain stable for each term portfolio when more variables are included in the model. This indicates that the market valuates long-term macroeconomic trends in government bond prices more than short-term trends, which could potentially stem from the fact that the strategy relies on the continuity of macroeconomic trends rather than trend reversals. The lower market factor loading in the short-term portfolio could also be explained by the fact that the market prices long-term macroeconomic trends in government bond prices while the short-term macroeconomic trends captured by the macroeconomic momentum strategy could sometimes be affected by noise in the economic data.

Table 12. Regression results for the unhedged term excess returns, factor estimates, and t-values are reported (in brackets). The dependent variables used in the regressions are excess returns from the value-weighted market index, excess returns of the term-corresponding macroeconomic momentum strategy in FX (FX MM), and excess returns from government bond carry, price momentum and value strategies. All regressions use Newey-West standard errors that account for conditional heteroscedasticity and serial correlation with up to 3 lags. Alpha is annualized.

Unhedged returns

Pane 1: Short-term lookbacks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Alpha	0.127	0.354	1.639	0.823	0.918	1.014	0.815	0.192	0.214	0.36	0.263
	(0.161)	(0.486)	(2.251 *)	(0.966)	(1.143)	(1.249)	(0.953)	(0.297)	(0.342)	(0.58)	(0.4)
Bond index	0.322							0.297	0.286	0.282	0.291
	(4.707 ***)							(4.846 ***)	(4.785 ***)	(4.738 ***)	(4.982 ***)
FX MM		0.491						0.468	0.47	0.459	0.454
		(5.372 ***)						(6.449 ***)	(6.557 ***)	(6.358 ***)	(6.264 ***)
DXY			0.21					0.197	0.2	0.206	0.204
			(4.946 ***)					(5.372 ***)	(5.573 ***)	(5.697 ***)	(5.506 ***)
Carry				0.123			0.175	0.035			0.08
				(1.271)			(1.845 .)	(0.462)			(1.079)
Momentum					0.054		0.001		0.055		-0.018
					(0.723)		(0.008)		(0.925)		(-0.281)
Value						-0.127	-0.16			-0.142	-0.165
						(-1.894 .)	(-2.001 *)			(-2.349 *)	(-2.315 *)
Adj. R-squared	0.059	0.173	0.190	0.003	-0.001	0.007	0.011	0.399	0.400	0.393	0.409
n	376	376	376	376	376	376	376	376	376	376	376

Pane 2: Medium-term lookbacks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Alpha	0.39	0.779	2.548	1.319	1.437	1.599	1.203	0.498	0.626	0.784	0.598
	(0.399)	(0.887)	(2.966 **)	(1.226)	(1.408)	(1.56)	(1.123)	(0.697)	(0.914)	(1.168)	(0.853)
Bond index	0.444							0.43	0.414	0.408	0.424
	(4.813 ***)							(6.157 ***)	(6.121 ***)	(6.187 ***)	(6.073 ***)
FX MM		0.542						0.525	0.522	0.515	0.513
		(6.694 ***)						(8.951 ***)	(8.667 ***)	(8.597 ***)	(8.922 ***)
DXY			0.314					0.294	0.3	0.307	0.302
			(6.235 ***)					(8.197 ***)	(8.498 ***)	(8.814 ***)	(8.514 ***)
Carry				0.193			0.264	0.095			0.149
				(1.458)			(2.073 *)	(0.833)			(1.511)
Momentum					0.117		0.085		0.05		-0.035
					(1.013)		(0.745)		(0.552)		(-0.435)
Value						-0.141	-0.149			-0.168	-0.211
						(-1.553)	(-1.452)			(-2.054 *)	(-2.53 *)
Adj. R-squared	0.072	0.199	0.272	0.006	0.002	0.005	0.015	0.524	0.523	0.532	0.535
n	376	376	376	376	376	376	376	376	376	376	376

Pane 3: Long-term lookbacks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Alpha	0.841	1.4	3.351	1.68	1.97	2.107	1.489	1.147	1.328	1.498	1.198
	(0.788)	(1.341)	(3.784 ***)	(1.444)	(1.778 .)	(1.905 .)	(1.296)	(1.43)	(1.723 .)	(1.979 *)	(1.525)
Bond index	0.474							0.492	0.467	0.464	0.481
	(4.213 ***)							(5.956 ***)	(5.868 ***)	(5.924 ***)	(5.791 ***)
FX MM		0.477						0.48	0.482	0.483	0.474
		(5.734 ***)						(9.463 ***)	(9.157 ***)	(9.119 ***)	(9.403 ***)
DXY			0.399					0.381	0.389	0.396	0.389
			(8.402 ***)					(10.227 ***)	(10.69 ***)	(10.958 ***)	(10.641 ***)
Carry				0.335			0.4	0.145			0.209
				(2.41 *)			(2.844 **)	(1.119)			(1.923 .)
Momentum					0.116		0.144		0.082		0.006
					(0.857)		(1.044)		(0.751)		(0.06)
Value						-0.074	-0.078			-0.179	-0.212
						(-0.761)	(-0.727)			(-1.896 .)	(-2.375 *)
Adj. R-squared	0.066	0.130	0.354	0.017	0.001	-0.001	0.023	0.548	0.546	0.554	0.559
n	376	376	376	376	376	376	376	376	376	376	376

However, the adjusted R-squared values of the single-factor models with the market factor remain low compared to the FX variables across all term portfolios, which repeats the findings with the measure portfolios that FX risk is a substantial driver of the macroeconomic momentum returns in the government bond market. The FX macroeconomic momentum term portfolios receive robust and positive coefficient estimates across all term portfolios varying in a narrow range around 0.5, which are also statistically significant at the 0.01 % level. The coefficient estimates are the largest of any variable in the short-term and medium-term portfolios while the long-term portfolio's bond market factor coefficient estimate is at the same level as its FX macroeconomic momentum term portfolio's coefficient estimate. This highlights the substantial impact the excess returns of the alpha-generating FX macroeconomic momentum strategy have on the excess returns of the strategy in the government bond market, and potentially in other asset classes as well, as the weights of the strategy's allocation is not dependent on the asset class, rather on sample selection and macroeconomic indicators. The DXY index also receives robust and positive coefficient estimates across all term portfolios, these estimates are also statistically significant at the 0.01 % level. There's a similar upward trend in the coefficient estimates to the bond market factor coefficient estimates, when the lookbacks are made longer, indicating that longer-term economic trends are more valued by the market, both in the government bond and in the FX market.

The zero-cost bond factor portfolios of carry, price momentum and value do not show robust effects on the macroeconomic momentum term portfolios, and their adjusted R-squared values are near-zero. This highlights my finding that the excess returns of the zero-cost bond factor portfolios mostly show statistically significant effects on the excess returns of the macroeconomic momentum portfolios strongly dependent on the selected measure. This is contradicting to Dahlquist and Hasseltoft's (2019) findings in the FX market and shows that the strategy potentially has limited number of unifying factors across different asset classes. The slight exception to this is the value factor which receives robust negative coefficient estimates across all terms and therefore also potentially across the measures of economic activity, inflation and combo. The coefficient estimates vary in a relatively stable range between -0.142 to -0.212 while they are statistically significant at the 5 % level when the bond market factor and FX factors are controlled for. This finding provides evidence to my hypothesis that the strategy is structurally short on the value factor and is still contradicting to Dahlquist and Hasseltoft's (2019) finding that the macroeconomic momentum strategy is long the value factor in the FX market.

6.4 Returns drivers of the currency-hedged measure and term returns

Table 13 reports the correlation matrix for the currency-hedged variables, the only changes to the correlation matrix in **Table 10** are that the dependent variables of excess returns of bond macroeconomic momentum portfolios are now currency-hedged, and the FX variables are removed as the currency-hedged bond returns do not have any FX risk.

Table 13. Correlation matrix of the currency-hedged variables. Upper triangle shows the Pearson correlation coefficients and the lower triangle the p-value of the coefficients according to the Student t-test. From left to right: 1st **panel:** Excess returns of currency-hedged bond macroeconomic momentum portfolios (economic activity, inflation, combo and aggregated term portfolios) 2nd **panel:** Excess returns of currency-hedged bond benchmark portfolios (carry, price momentum, value and value-weighted market index)

		Bond macroeconomic momentum, dependent variables						Bond independent variables			
		EA	Inflation	Combo	Short	Med	Long	Carry	Momentum	Value	Market
Bond macroeconomic momentum, dependent variables	EA		0.93	0.99	0.57	0.58	0.54	0.03	0.06	-0.09	0.88
	Inflation	(0.00)		0.96	0.53	0.54	0.54	0.21	0.02	-0.03	0.85
	Combo	(0.00)	(0.00)		0.58	0.59	0.56	0.09	0.05	-0.08	0.87
	Short-term	(0.00)	(0.00)	(0.00)		0.86	0.75	0.01	0.08	-0.29	0.38
	Med-term	(0.00)	(0.00)	(0.00)	(0.00)		0.94	0.03	0.05	-0.23	0.38
	Long-term	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		0.02	0.06	-0.22	0.37
Bond independent variables	Carry	(0.34)	(0.00)	(0.16)	(0.81)	(0.60)	(0.66)		-0.22	0.25	-0.13
	Momentum	(0.02)	(0.84)	(0.12)	(0.14)	(0.34)	(0.25)	(0.00)		-0.51	0.13
	Value	(0.00)	(0.37)	(0.04)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)		-0.07
	Market	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.17)	

The main difference with the currency-unhedged correlation matrix are that the bond market factor receives a substantial increase in its correlation coefficients with all the macroeconomic momentum measure portfolios: the correlation coefficients jump from the range of 0.22 - 0.27 to 0.85 - 0.88. Reflecting this remarkable change to the bond market correlation coefficients of the measure portfolios, the term portfolios' market correlation on the contrary does not increase as substantially when hedging for FX risk: the correlation estimates rise from 0.25 – 0.27 to 0.36 – 0.37. This provides some further evidence that there is a limited number of unifying factors across the three measures of inflation, economic activity and combo, and that an investor is able to reduce his exposure to market risk by combining the different measure into his portfolio to increase diversification benefits. Also the fact, that the measure portfolios show varying correlation dynamics with the zero-cost bond factor portfolios of carry, price momentum and value, highlights the underlying differences of the return drivers of the measure portfolios. The inflation measure portfolio has a statistically significant correlation coefficient of 0.21 with the carry portfolio while the economic activity measure portfolio has statistically significant correlation coefficients with the price momentum and value portfolios (0.06 and -0.09 respectively), and the combo measure portfolio has a statistically significant correlation coefficient of -0.08 with the value portfolio. While the inflation measure portfolio is the only independent variable that shows persistency in its dependence on the carry factor, the value factor retains its status as the most significant unifying factor across measure and term portfolios.

6.4.1 Measure returns

The linear regression results for the currency-hedged measure portfolio returns are reported in **Table 14.** Similar to the regressions of currency-unhedged returns, the regressions use Newey-West standard errors with a lag of 3 and the regressions are controlled for statistically significant multicollinearity by the variance inflation statistic. The linear models tested with the currency-hedged macroeconomic momentum portfolios follow the same principle as with the previous sub-chapters: models 1-4 are single-factor models and models 5-9 are multi-factor tests with the bond factor portfolios.

The regression results show promising evidence for my hypotheses, that was not evident from the regressions with the currency-unhedged macroeconomic momentum portfolio returns. With currency-hedged macroeconomic momentum measure portfolios the carry factor receives positive and statistically very significant coefficient estimates across all measures when the market factor is controlled for. Similar to my findings with the currency-unhedged measure portfolios however, the inflation measure's carry coefficient estimate is considerably higher (0.463 in the full model) than economic activity and combo measure's carry factor loadings (0.201 and 0.279 respectively in the full models). The carry factor's coefficient estimate is also statistically significant in a single-factor model only with the inflation measure, and its adjusted R-squared value is considerably higher (0.043) than with economic activity and combo measure's single-factor carry models (-0.001 and 0.005). These findings are provided ground by past literature as stronger past macroeconomic trends, both inflation as well as output indicators, should steepen yield curves and weak trends flatten as past fundamentals influence future expectations. (e.g. Fisher et al, 1925) As yield curve steepness translates into carry based on Koijen et al. (2018) it is expected that all the macroeconomic momentum measures would capture the carry factor.

Table 14. Regression results for the hedged measure excess returns, factor estimates and t-values are reported (in brackets). The dependent variables used in the regressions are excess returns from the currency-hedged value-weighted market index and excess returns from currency-hedged government bond carry, price momentum and value strategies. All regressions use Newey-West standard errors that account for conditional heteroscedasticity and serial correlation with up to 3 lags. Alpha is annualized.

Hedged returns

Panel 1: Inflation measure

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Alpha	0.066 (0.201)	2.070 (3.04 **)	2.404 (3.451 ***)	2.439 (3.632 ***)	2.018 (2.988 **)	-0.590 (-2.025 *)	0.129 (0.393)	0.052 (0.154)	-0.511 (-1.93 .)
Bond index	0.902 (21.346 ***)					0.945 (28.371 ***)	0.914 (20.877 ***)	0.904 (21.26 ***)	0.949 (29.868 ***)
Carry		0.297 (3.784 ***)			0.334 (3.734 ***)	0.452 (9.881 ***)			0.463 (11.22 ***)
Momentum			0.023 (0.269)		0.038 (0.441)		-0.098 (-1.809 .)		-0.071 (-1.576)
Value				-0.037 (-0.567)	-0.082 (-1.202)			0.028 (0.751)	-0.094 (-2.662 **)
Adj. R-squared	0.715	0.043	-0.002	-0.001	0.047	0.819	0.722	0.715	0.824
n	376	376	376	376	376	376	376	376	376

Panel 2: Economic activity measure

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Alpha	-0.129 (-0.518)	2.086 (3.293 **)	2.079 (3.247 **)	2.168 (3.522 ***)	2.039 (3.253 **)	-0.405 (-1.591)	-0.095 (-0.384)	-0.117 (-0.468)	-0.327 (-1.364)
Bond index	0.867 (31.839 ***)					0.885 (35.761 ***)	0.873 (33.317 ***)	0.865 (32.105 ***)	0.888 (37.358 ***)
Carry		0.045 (0.614)			0.081 (0.959)	0.190 (4.895 ***)			0.201 (5.501 ***)
Momentum			0.062 (0.758)		0.033 (0.38)		-0.053 (-1.331)		-0.070 (-1.704 .)
Value				-0.084 (-1.285)	-0.083 (-1.299)			-0.022 (-0.813)	-0.094 (-2.95 **)
Adj. R-squared	0.780	-0.001	0.001	0.005	0.003	0.802	0.783	0.780	0.808
n	376	376	376	376	376	376	376	376	376

Panel 3: Combo measure

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Alpha	-0.160 (-0.585)	2.039 (3.057 **)	2.127 (3.15 **)	2.204 (3.407 ***)	1.996 (3.027 **)	-0.547 (-1.986 *)	-0.117 (-0.431)	-0.153 (-0.556)	-0.462 (-1.819 .)
Bond index	0.893 (30.05 ***)					0.919 (36.75 ***)	0.902 (31.111 ***)	0.892 (30.413 ***)	0.922 (39.737 ***)
Carry		0.115 (1.508)			0.153 (1.74 .)	0.266 (6.401 ***)			0.279 (7.168 ***)
Momentum			0.052 (0.611)		0.030 (0.347)		-0.067 (-1.518)		-0.076 (-1.701 .)
Value				-0.078 (-1.126)	-0.092 (-1.337)			-0.014 (-0.477)	-0.103 (-3.173 **)
Adj. R-squared	0.764	0.005	0.000	0.003	0.010	0.803	0.767	0.763	0.809
n	376	376	376	376	376	376	376	376	376

The value factor continues to provide further evidence for my hypothesis that the macroeconomic momentum is short on value, that allocates long positions in countries' sovereign bonds whose yields have risen the most during the past 5 years while allocating short positions in countries' sovereign debt whose yields have fallen the most during the past 5 years. This is due to the fact that positive economic signals should increase sovereign yields, either by rising expectations of higher short-term interest rates or by higher risk premia or expected inflation rates. As the macroeconomic momentum strategy takes the opposite investment side as the value factor in this case, the negative and somewhat robust coefficient estimate for the value factor is justified across measure portfolios. However, as negative macroeconomic signals could also trigger rising yields, and therefore price depreciation of bonds, in the case of for example a rising default probability of an economy, the allocations of the macroeconomic momentum portfolios and the value portfolio sometimes potentially take the same side of investment. Therefore, the value factor's robustness is not on the same level as for example the market factor or the carry factor's robustness. Nevertheless, the value factor receives statistically significant coefficient estimates at the 1 % level for each measure portfolio in the full models of the regression 9. These coefficient estimates are stable at -0.094 for the inflation and economic activity measures, -0.103 for the combo measure.

The price momentum factor's coefficient estimates also show some stabilization in the full models for each measure even as the estimates remain statistically insignificant at the 5 % level. As Dahlquist and Hasseltoft (2019) find that the excess returns of the macroeconomic momentum strategy does not load statistically significantly for price momentum in the FX markets, I may conclude based on consistent findings that the same strategy does show such a dynamic in the government bond market as well as the factor loadings have constantly been statistically insignificant at the 5 % level and the estimates have been near-zero.

But the most impactful difference between the strategy's dynamics in the FX and government bond markets proves to be the market factor. The currency-hedged market factor receives substantially higher coefficient estimates than the zero-cost bond factors of carry, price momentum and value, and the adjusted R-squared values in the excess of 0.7 show that macroeconomic momentum measure government bond portfolios have very high market exposures even as they are long-short portfolios that attempt to be market-neutral. Even as I have shown evidence for my hypotheses that carry and negative value are captured by the strategy, the most impactful bond factor is unquestionably the market factor, as the adjusted R-squared values of the single-factor models for each zero-cost bond factor and of the models with only zero-cost bond factors reach at best 0.043.

The main reason, why the strategy has high market exposure stems from the finding of Driessen et al. (2000) that sovereign yields correlate highly together through a ‘global factor’. It also could be, that past macroeconomic trends are highly priced-in by the government bond market. As Dahlquist and Hasseltoft (2019) did not include a market factor variable in their study of the macroeconomic momentum strategy in the FX market, a very interesting addition to their study would be to implement one. As I show in **Chapter 6.3**, the DXY could potentially serve as one while the FX market’s market factor depends on the domestic currency and is not universal throughout currencies.

Lastly, the alpha found in the currency-unhedged inflation measure portfolio vanishes when the FX risk is absolutely controlled for by using currency-hedged macroeconomic momentum excess returns. The alphas found in **Table 14** are statistically insignificant at the 5 % level when the market factor is controlled for and even show some tendency to being negative and partly statistically significant at the 10 % level. This shows that the relatively robust alpha found in **Chapter 6.3.1** with the inflation measure portfolio either is solely-dependent on FX risk or that the model setup was biased enough due to the exclusion of the FX risk incorporated in the bond factor portfolios and the potentially significant multicollinearity issues their inclusion could have incurred. The latter argument can be drawn from the substantial increases in model fits, as the full models show adjusted R-squared values in excess of 0.8, while the models that fitted currency-unhedged measure portfolio returns showed adjusted R-squared values between 0.60 and 0.40. Given also that the alphas found in the FX market by Dahlquist and Hasseltoft (2019) were statistically and economically significant and I find somewhat negative alphas for the currency-hedged bond strategy returns, the alphas of the currency-unhedged macroeconomic momentum measure portfolios were mostly indistinguishable from zero, and it could be justified to argue that the strategy does not perform equally well in the government bond market than in the FX market.

6.4.2 Term returns

The linear regression results for the currency-hedged term portfolio returns are reported in **Table 15.** Similar to the regressions of currency-unhedged returns, the regressions use Newey-West standard errors with a lag of 3 and the regressions are controlled for statistically significant multicollinearity by the variance inflation statistic.

Table 15. Regression results for the hedged term excess returns, factor estimates, and t-values are reported (in brackets). The dependent variables used in the regressions are excess returns from the value-weighted market index, excess returns of the term-corresponding macroeconomic momentum strategy in FX (FX MM), and excess returns from government bond carry, price momentum and value strategies. All regressions use Newey-West standard errors that account for conditional heteroscedasticity and serial correlation with up to 3 lags. Alpha is annualized.

Hedged returns

Panel 1: Short-term lookbacks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Alpha	-0.421 (-1.446)	0.104 (0.31)	0.076 (0.228)	0.166 (0.554)	0.156 (0.514)	-0.484 (-1.579)	-0.430 (-1.496)	-0.350 (-1.335)	-0.400 (-1.513)
Bond index	0.205 (6.285 ***)					0.209 (6.078 ***)	0.203 (5.922 ***)	0.195 (6.227 ***)	0.209 (6.318 ***)
Carry		0.009 (0.188)			0.055 (1.109)	0.043 (0.872)			0.083 (1.93 .)
Momentum			0.040 (1.009)		-0.046 (-1.537)		0.013 (0.305)		-0.070 (-2.437 *)
Value				-0.148 (-4.635 ***)	-0.181 (-5.031 ***)			-0.134 (-3.938 ***)	-0.184 (-5.041 ***)
Adj. R-squared	0.159	-0.002	0.003	0.081	0.089	0.161	0.157	0.224	0.250
n	376	376	376	376	376	376	376	376	376

Panel 2: Medium-term lookbacks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Alpha	-0.397 (-1.155)	0.226 (0.575)	0.224 (0.579)	0.306 (0.837)	0.285 (0.77)	-0.494 (-1.331)	-0.397 (-1.177)	-0.329 (-0.99)	-0.399 (-1.16)
Bond index	0.249 (5.447 ***)					0.256 (5.24 ***)	0.249 (5.048 ***)	0.240 (5.155 ***)	0.256 (5.067 ***)
Carry		0.025 (0.395)			0.070 -1.115	0.067 (1.02)			0.105 (1.841 .)
Momentum			0.033 (0.557)		-0.051 (-0.988)		0.000 (0.006)		-0.080 (-1.348)
Value				-0.145 (-3.426 ***)	-0.184 (-4.018 ***)			-0.127 (-2.897 **)	-0.187 (-4.451 ***)
Adj. R-squared	0.152	-0.002	0.000	0.049	0.056	0.157	0.150	0.190	0.214
n	376	376	376	376	376	376	376	376	376

Panel 3: Long-term lookbacks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Alpha	-0.338 (-0.909)	0.344 (0.826)	0.328 (0.799)	0.423 (1.099)	0.394 (1.005)	-0.435 (-1.073)	-0.343 (-0.936)	-0.266 (-0.733)	-0.343 (-0.909)
Bond index	0.271 (5.04***)					0.277 (4.837***)	0.270 (4.583***)	0.261 (4.695***)	0.277 (4.571***)
Carry		0.022 (0.299)			0.070 (1.034)	0.067 (0.879)			0.108 (1.707.)
Momentum			0.043 (0.589)		-0.045 (-0.758)		0.007 (0.085)		-0.077 (-1.102)
Value				-0.155 (-2.848**)	-0.191 (-3.449***)			-0.136 (-2.3*)	-0.194 (-3.708***)
Adj. R-squared	0.147	-0.002	0.001	0.046	0.050	0.150	0.145	0.182	0.201
n	376	376	376	376	376	376	376	376	376

The exclusion of FX risk improves the robustness of the value factor dramatically as the estimates mostly become statistically significant at the 0.1 % level while they retain a stable level of around -0.15 to -0.20 across term portfolios. This gives further evidence that the negative value factor is one of the limited unifying factors across macroeconomic momentum measures in the government bond market. Another such a unifying factor stands out to be the market factor which continues to receive positive estimates that are statistically significant at the 0.1 % level. However, the factor estimates are slightly lower than with currency-unhedged term portfolios and drastically lower than with measure portfolios. This is evidence that the huge market exposure found in measure portfolios can be hedged for by diversifying across measures and more specifically within similar lookback lengths.

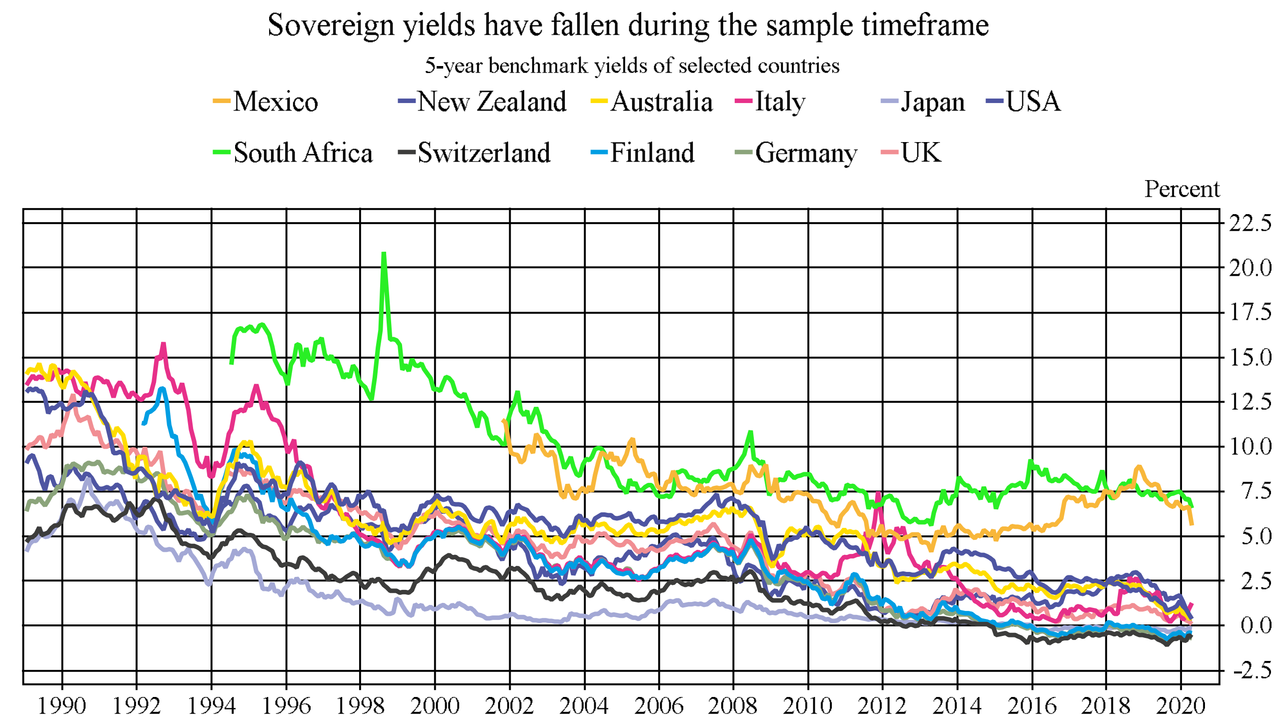
The carry factor struggles to receive similar coefficient estimates than found in the measure portfolio returns, as the coefficient estimates range from 0.083 to 0.108 when the lookbacks are increased from short-term to long-term and shows a slight upward trend. One of the reasons why carry is an impactful factor in currency-hedged measure portfolio returns across all measures but struggles in aggregated term portfolios, could lie in the heavier weight of longer lookbacks that measure portfolios have, or that the diversification within different measures also somewhat hedges the carry exposure. Overall, the lowest adjusted R-squared values I find in this thesis show evidence that the different macroeconomic momentum measures show very different dynamics in the government bond market, dissimilar to Dahlquist and Hasseltoft (2019) findings in the FX market, due to the potential hedging of each other's risk exposures, which could be taken advantage of.

7 Robustness checks

Next I will conduct several robustness checks to test whether my results are affected by changes in the sample's timeframe or list of countries. The analysis on time-based sub-samples is done by taking rolling 10-year sub-samples each month starting from 12/1998 and testing the monthly excess returns of the macroeconomic momentum portfolios, both measure and the aggregated term portfolios and currency-unhedged as well as currency-hedged excess returns, with the full linear regression models that use the all the independent variables, i.e. regression 11 of **Table 11 and 12** for currency-unhedged excess returns**,** regression 9 of **Table 14 and 15** for currency-hedged excess returns. The regressions use Newey-West standard errors with up to 3 lags and the models are tested for statistically significant multicollinearity with the variance inflation statistic. This robustness check is potentially crucial, as the government bond market conditions have changed during the past 30 years remarkably, as interest rates have fallen considerably (**Figure 14)** since the past few decades and the G4 central banks; the

Federal Reserve, European Central Bank, Bank of Japan and Bank of England, have initialized quantitative easing programs that have seen them buy trillions of U.S. dollars' worth of bonds, especially government bonds (**Figure 15**).

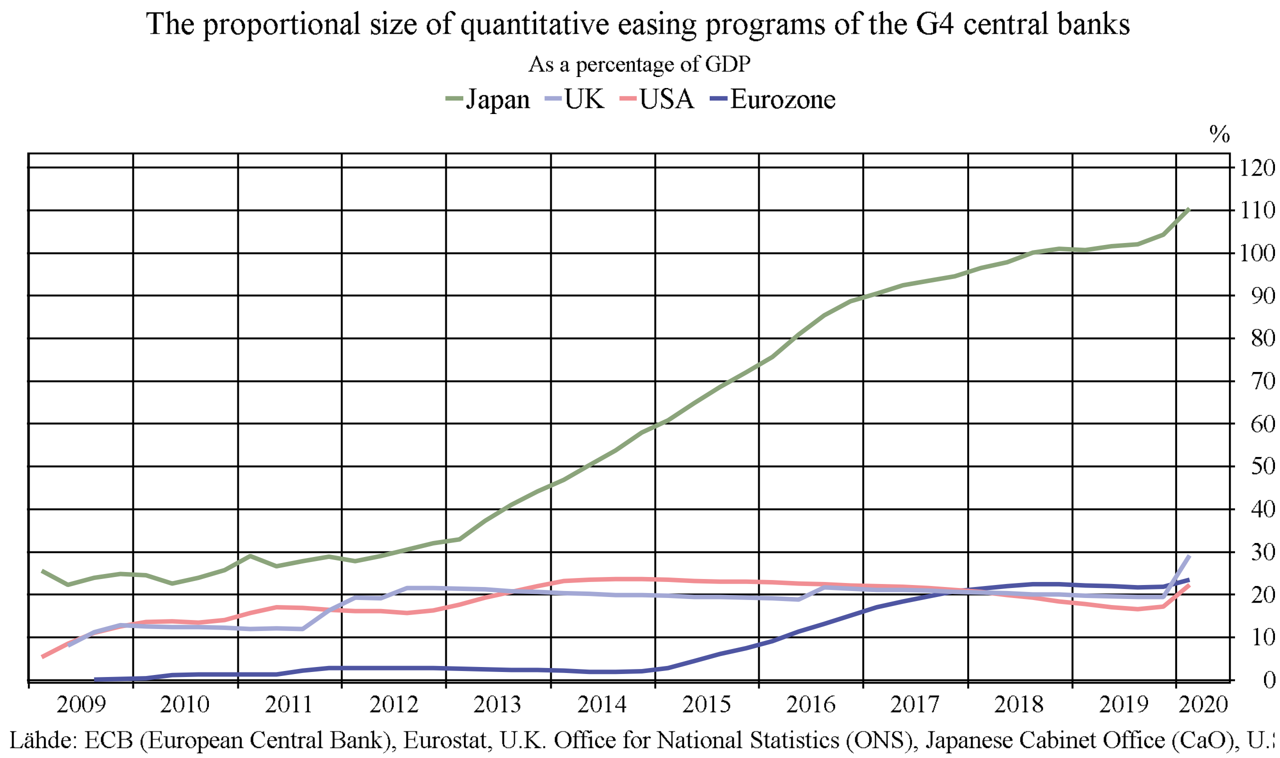
Figure 14.



Sources: Macrobond Financial AB, Reserve Bank of New Zealand, Bloomberg.

Secondly, I split my sample into two groups of countries and form the macroeconomic momentum portfolios, both measure and aggregated term, and analyze their performance in comparison to the full sample's performance as in **Chapter 6.1 and 6.2**. The split is done into G4 countries (USA, UK, Germany, France, Italy, Spain, Portugal, the Netherlands, Belgium, Austria, Ireland, Finland and Japan) and the rest (Australia, Canada, Czechia, Denmark, Hungary, Mexico, New Zealand, Norway, Poland, South Africa, South Korea, Sweden and Switzerland), which results in even-numbered samples of 13 countries each. Dahlquist and Hasseltoft (2019) find that their findings of the macroeconomic momentum strategy in the FX market are robust also in smaller sub-samples of countries, so given that there is some unifying factors between macroeconomic momentum's performance in the FX and government bond markets, I would also assume to have robust results regardless of the sample of countries. Finding inconsistent results between the sub-samples and the full sample would show that macroeconomic momentum performs relatively unpredictably in the government bond market compared to the FX market.

Figure 15.



7.1 Sub-samples per time frame, unhedged returns

Figure 16 show the coefficient estimates (left-side) and their t-values (right-side) through time with the x-axis representing the end period of the regression sample, for the currency-unhedged measure portfolios, while **Figure 17** reports the results for the aggregated term portfolios.

The market factors for both the bond and FX markets show across all measures declines in coefficient estimates starting from the 10-year sub-samples that end around 2010. The market factors' t-values have also steadily decreased in the sub-samples ending after 2010 and the bond market factor is not significant at the 5 % level for any measure at least in the latest sub-samples that end around 2020, while the DXY index holds to be statistically significant at the 5 % level for the inflation measure portfolio in all sub-samples. This is not in line with the findings of Driessen et al. (2000) that sovereign yields are heavily influenced by a 'global factor', but given the significant changes in the financial markets after their study was released, this could be the reason. A similar decline of the bond factor's coefficient can be seen with the aggregated term portfolios, which further strengthens the argument that the factor's decline is a unifying factor across measure's and lookback periods.

The decline of the DXY index' coefficient estimate and robustness is complemented by the increase in the FX macroeconomic momentum's coefficient estimate and robustness in sub-samples ending around 2010, a very similar movement can also be found with the aggregated term portfolios in **Figure 15.** This could happen due to the adoption of the euro in the Eurozone in 1999 and its member states' yield harmonization for the first 10 years of the eurozone's existence or by the fact that central banks especially in G4 have diminished the use of Taylor rules due to low inflationary pressures while their policy rates have hovered near the effective lower bound of interest rates, and have taken on unconventional monetary policy measures such as quantitative easing. These unconventional measures are not accounted by conventional Taylor rules, which set the policy rate as a function of the central bank's deviation from its inflation and economic output goals (Taylor 1994) and are argued to be a crucial driver of the macroeconomic momentum returns in the FX market by Dahlquist and Hasseltoft (2019).

Out of the zero-cost bond factors carry and value show persistent coefficient estimates and robustness across measures, which gives further evidence for my hypotheses of their effects on the strategy's performance. The carry factor's coefficient estimate is across all measures statistically significant at the 5 % in almost all sub-samples while its coefficient estimates vary between 0.5-1 for the inflation measure. For the term portfolios the carry factor receives also high estimate values and shows robustness throughout the sub-samples across terms highlighting that the macroeconomic momentum strategy shares a high number of similarities with the carry strategy, as is also found by Dahlquist and Hasseltoft in their study of the strategy within the FX market.

The value factor is statistically not significant at the 5 % level for the first half of the sub-samples but turns statistically significant at the 5 % level after around 2010, a similar turning point than for the FX factors previously discussed. With the term portfolios there's a similar slight bump in the value factor's coefficient estimate across terms during the Great Financial Crisis, and the factor turns statistically significant only after the crisis. This highlights that the strategy shares similarities with carry as it loses the value attribute during crisis, when carry returns crash because of a liquidity squeeze and volatility spikes. Also, the economically significant alpha of several percentage points annualized, even in the excess of 4 %, of the inflation measure during the first half of sub-samples highlights that the 'Great Moderation' has dramatically diminished the excess returns of the macroeconomic momentum strategy, and that the positive and significant alpha seen in the initial regressions was mostly attributed to the first half of the timeframe.

Figure 16. Regression results for the unhedged excess returns of the measure portfolios, factor estimates are on the left side and t-values are on the right side The dependent variables used in the regressions are excess returns from the currency-unhedged value-weighted market index and excess returns from currency-unhedged government bond carry, price momentum and value strategies. All regressions use Newey-West standard errors that account for conditional heteroscedasticity and serial correlation with up to 3 lags. Alpha is annualized.

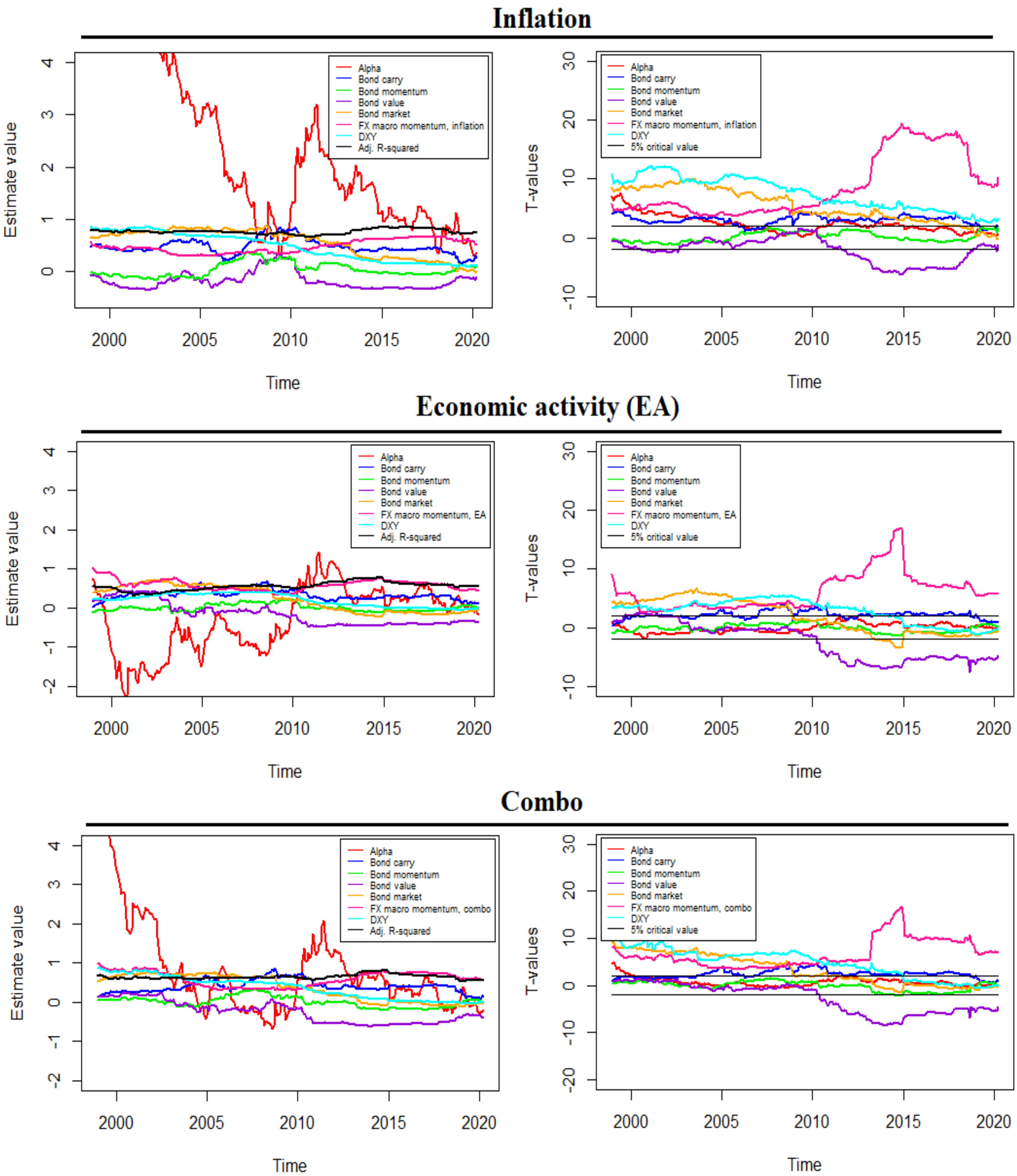
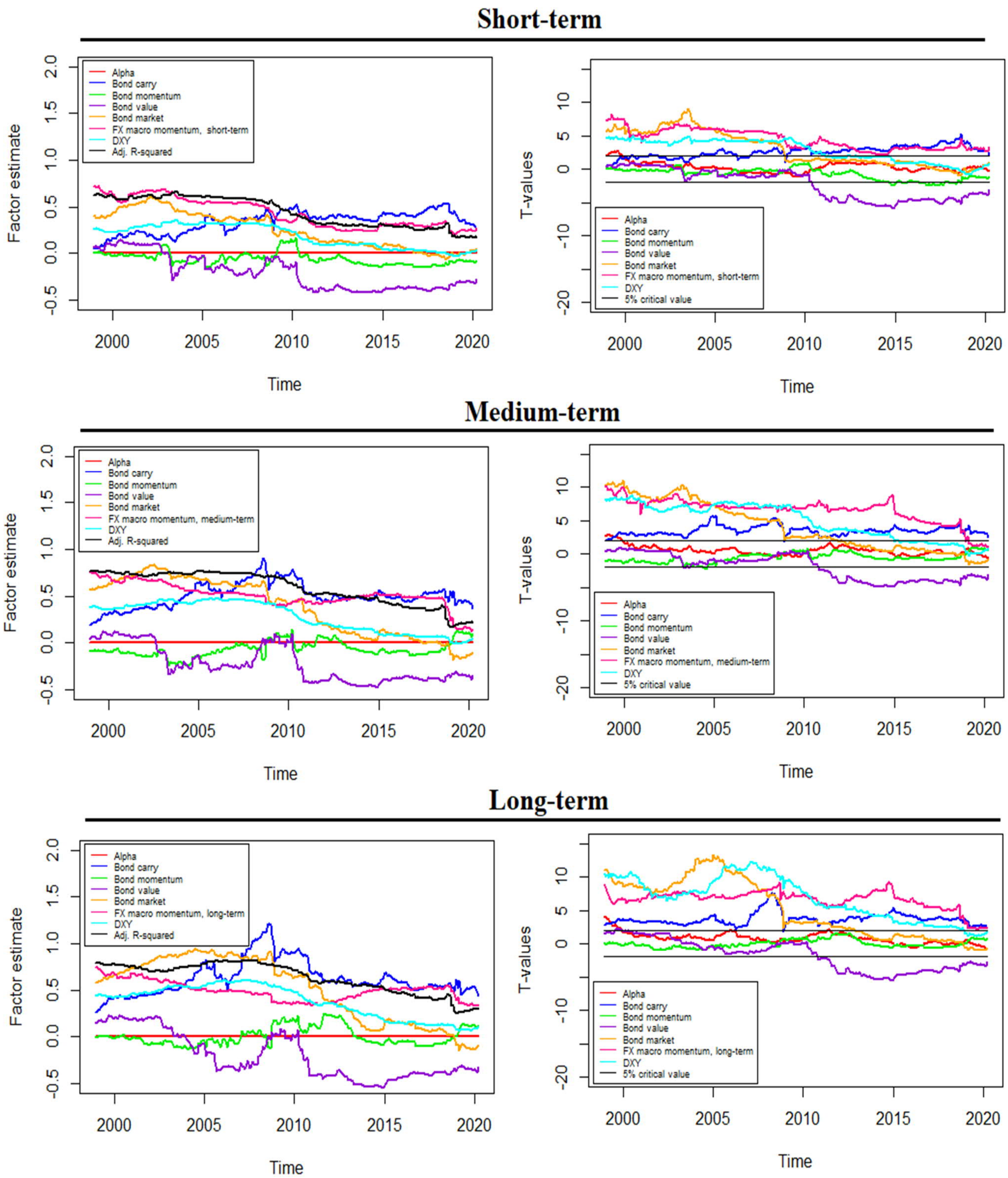


Figure 17. Regression results for the unhedged excess returns of the aggregated term portfolios, factor estimates are on the left side and t-values are on the right side The dependent variables used in the regressions are excess returns from the currency-unhedged value-weighted market index and excess returns from currency-unhedged government bond carry, price momentum and value strategies. All regressions use Newey-West standard errors that account for conditional heteroscedasticity and serial correlation with up to 3 lags. Alpha is annualized.



7.2 Sub-samples per time frame, hedged returns

Figure 18 shows the coefficient estimates (left-side) and their t-values (right-side) based on the rolling 10-year regression sub-samples through time with the x-axis representing the end period of the regression sub-sample for the currency-hedged measure portfolios, **Figure 19** shows the same statistics for the currency-hedged term portfolios.

Figure 18. Regression results for the hedged excess returns of the measure portfolios, factor estimates are on the left side and t-values are on the right side The dependent variables used in the regressions are excess returns from the currency-hedged value-weighted market index and excess returns from currency-hedged government bond carry, price momentum and value strategies. All regressions use Newey-West standard errors that account for conditional heteroscedasticity and serial correlation with up to 3 lags. Alpha is annualized.

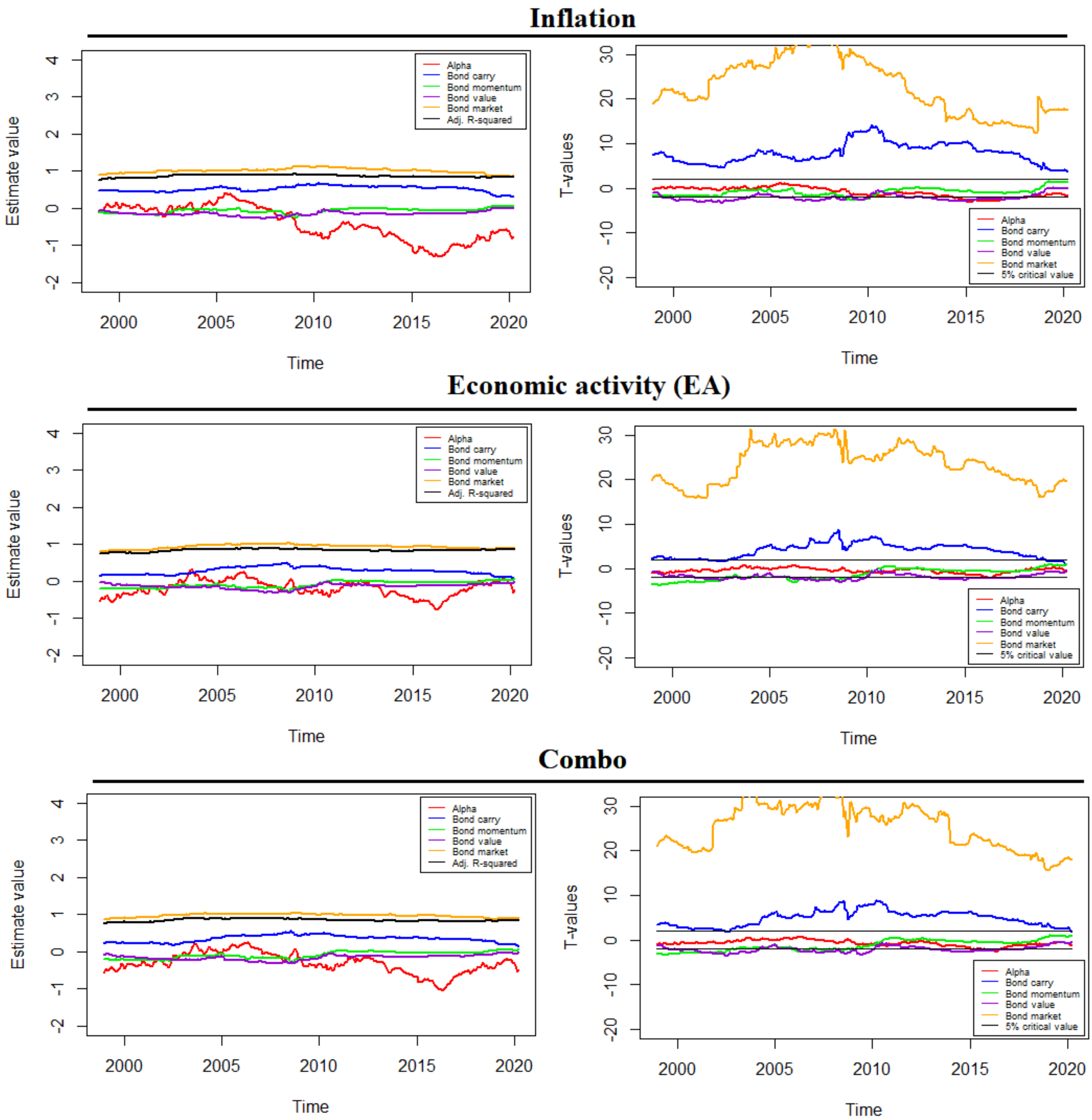
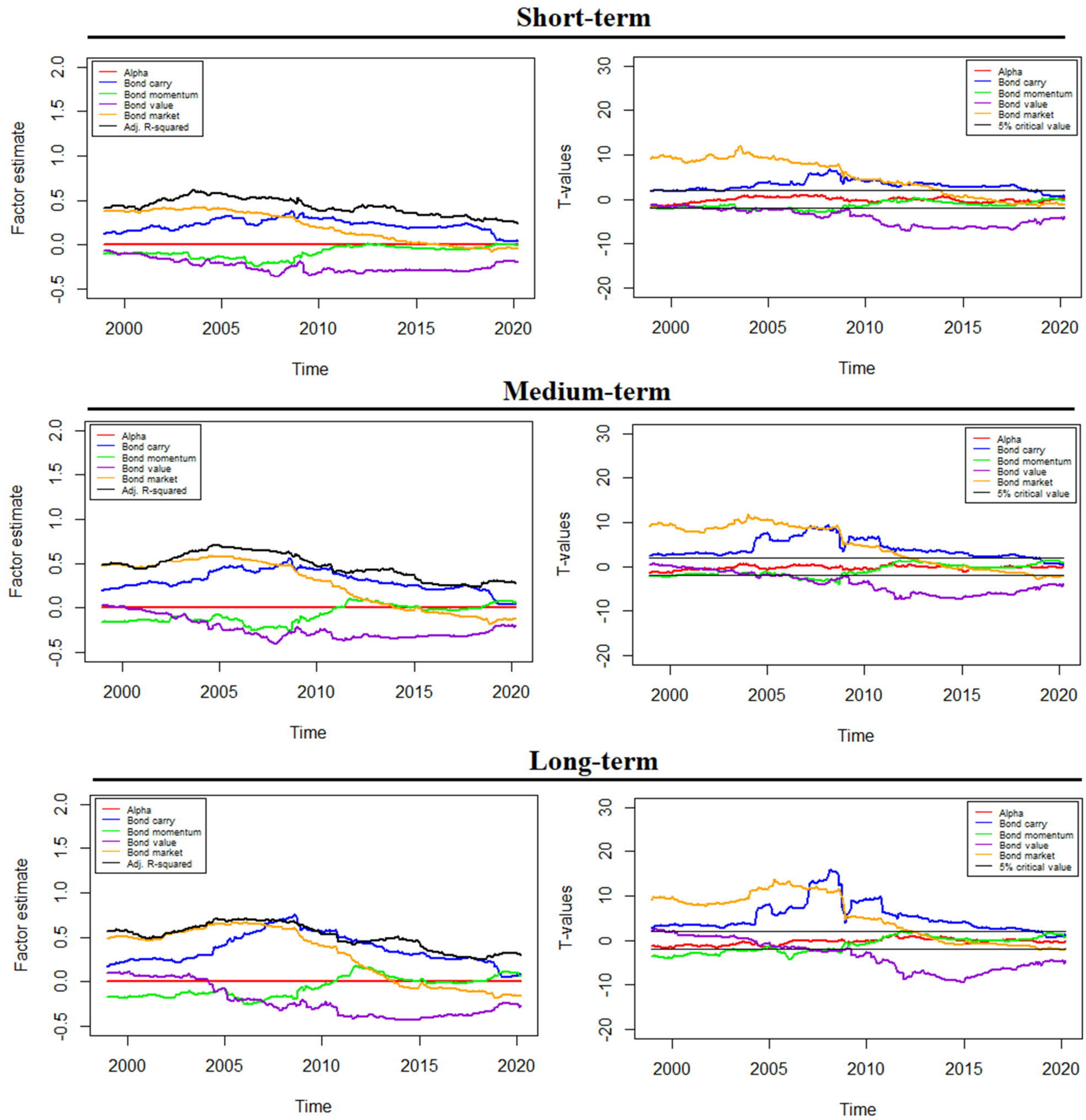


Figure 19. Regression results for the unhedged excess returns of the aggregated term portfolios, factor estimates are on the left side and t-values are on the right side The dependent variables used in the regressions are excess returns from the currency-hedged value-weighted market index and excess returns from currency-hedged government bond carry, price momentum and value strategies. All regressions use Newey-West standard errors that account for conditional heteroscedasticity and serial correlation with up to 3 lags. Alpha is annualized.



The currency-hedged term portfolios show a very similar story than with the currency-unhedged term portfolios but with more consistency as the FX risk is totally eliminated, possibly increasing the robustness of the model. Overall, the sub-samples give further evidence for my hypotheses, that carry and value are significant return drivers of the macroeconomic momentum strategy, and the initial results reported in **Chapter 6**: the carry factor shows statistical significance at the 5 % level throughout the sub-samples in each term portfolio, and the same is the case with value, even as the first half of the sum-samples show slightly weaker significance for the factor.

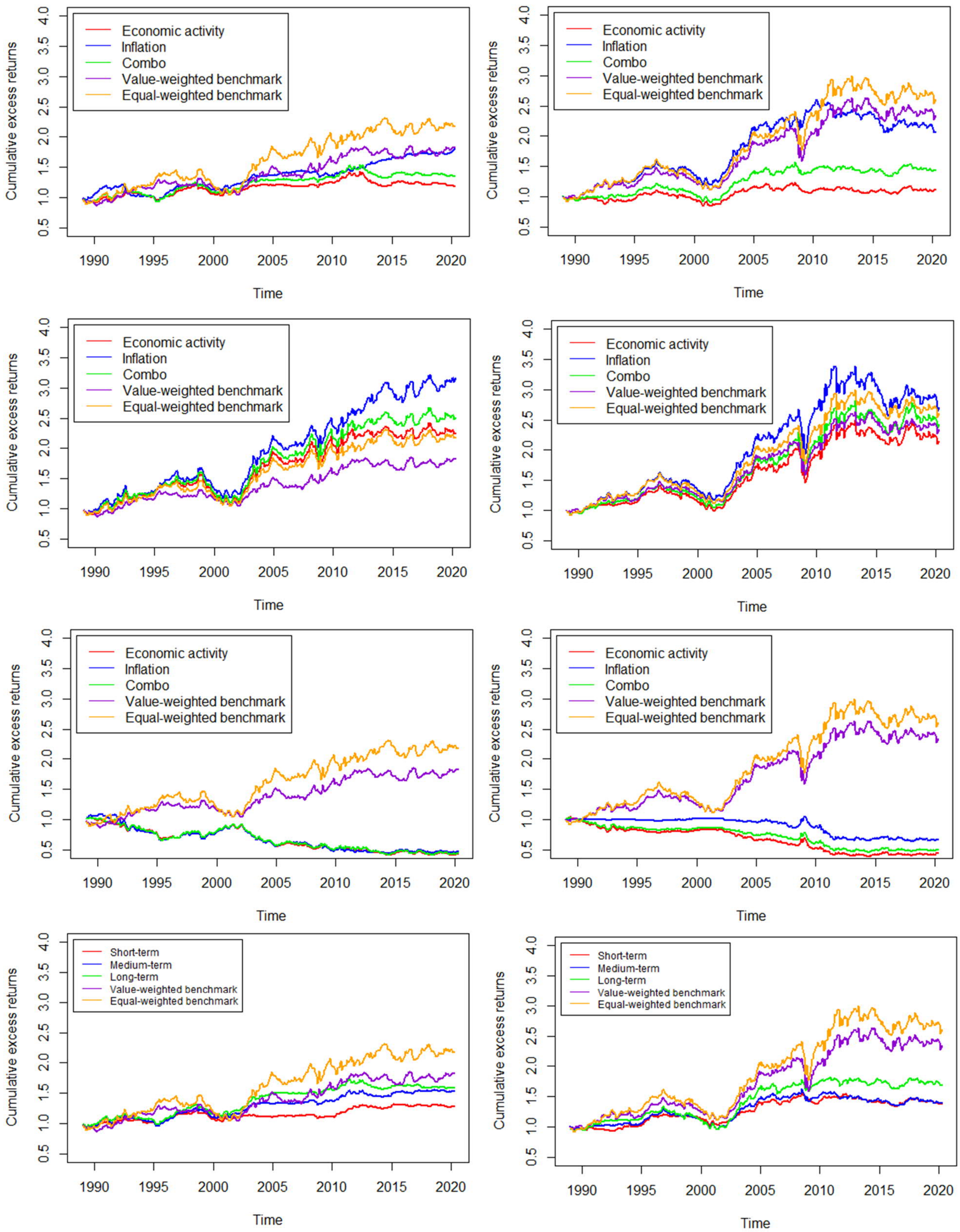
However, the market factor shows some contradicting signs between the currency-hedged term and measure portfolios, as the factor receives very stable coefficient estimates across measures and sub-samples, around 1.0, and the t-values are very high similar to the results in **Chapter 6.4.1,** but for term portfolios the factor shows a similar declining trend than with the currency-unhedged portfolios. This could provide some evidence, why the regression results in **Chapter 6.4.1** and **6.4.2** showed some potential diversification benefits when allocating in term portfolios. Also, the carry factor receives statistically very robust coefficient estimates across measures, terms and sub-samples, while the coefficient estimates vary within a narrow band with a slight increasing trend on the first half of sub-samples and a slight decreasing trend on the latter half of sub-samples. The value factor shows slight robustness with stable coefficient estimates mildly negative across measures, terms and sub-samples, with its statistical significance on the borderline of the 5 % level.

7.3 Sub-samples of countries, unhedged returns

Figure 20 shows the currency-unhedged cumulative excess returns of the long-short measure portfolios, the long measure portfolios, the short measure portfolios and the aggregated long-short term portfolios for the G4 group (left-side) and for the rest of the total sample (right-side) and **Figure 21** shows the Sharpe ratio, mean annualized excess returns and simple standard deviation of the long-short measure portfolios per lookback for the G4 (left-side) and the rest (right-side).

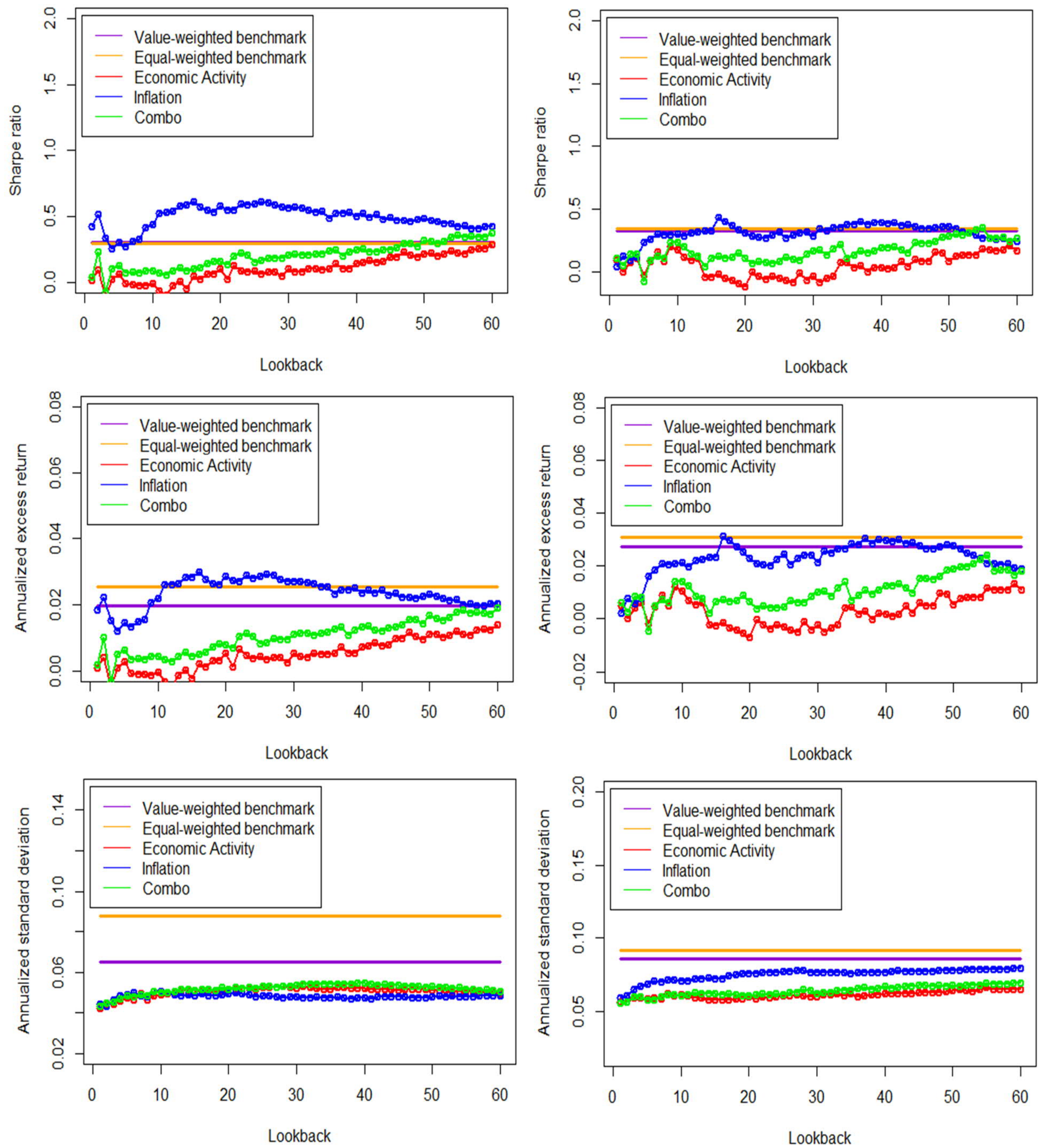
The main finding is that the mean annualized excess returns of the currency-unhedged measure portfolios are relatively balanced between the two groups with the G4 group showing relatively lower volatility of excess returns across lookbacks and measures compared to the rest of the sample. However, the patterns of the excess returns through time show great variation between the two groups. This can be seen in the cumulative excess returns of each macroeconomic momentum measure with the G4 cumulative excess returns relatively stable throughout the Great Financial Crisis whereas the measure portfolios formed from the rest of the countries show increased volatility during the crisis. Also, the G4 group's cumulative excess returns of the inflation measure show an interestingly flat and upwards-sloping excess returns curve after the Great Financial Crisis, which could be due to quantitative easing programs deployed by all of the G4 central banks in the after-shock of the crisis, while the inflation measure formed from the rest of the sample shows a decline in cumulative excess returns during those years. Within both sub-samples the inflation measure also underperforms the value-weighted market index in cumulative excess returns, against the finding in the main results which is due to the minimal excess returns during the yield harmonization of the Eurozone countries starting with the introduction of the euro and the sovereign yield harmonization and ending after the

Figure 20. The cumulative excess returns of currency-unhedged measure portfolios of G4 (left-side) and the rest (right-side). (From top to bottom) 1st row: Long-short measure portfolio and benchmark cumulative excess returns **2nd row:** Cumulative excess returns of the long positions of the measure portfolios. **3rd row:** Cumulative excess returns of the short positions of the measure portfolios. **4th row:** Cumulative excess returns of the aggregated term portfolios.



Great Financial Crisis. Even so, the currency-unhedged inflation measure portfolio of the G4 outperforms the value-weighted market index almost across all lookbacks in both mean annualized excess returns and risk-adjusted excess returns, similar to the main findings, while the excess returns on the currency-unhedged inflation measure portfolio formed from the rest of the sample countries generates at best similar mean annualized excess returns similar to the value-weighted index.

Figure 21. The mean annualized excess returns, standard deviation and Sharpe ratio of measure returns per lookback (G4 = left-side, rest = right-side) Top: Annualized Sharpe ratio. **Middle:** Mean annualized excess returns. **Bottom:** Annualized simple standard deviation of returns.



7.4 Sub-samples of countries, hedged returns

Figure 22 shows the currency-hedged cumulative excess returns of the long-short measure portfolios, the long measure portfolios, the short measure portfolios and the aggregated long-short term portfolios for the G4 group (left-side) and for the rest of the total sample (right-side) and **Figure 23** shows the Sharpe ratio, mean annualized excess returns and simple standard deviation of the long-short measure portfolios per lookback for the G4 (left-side) and the rest (right-side).

The currency-hedged portfolios' performance between the two groups show relatively similar returns to each other while the most significant finding is that the inflation measure underperforms the economic activity and combo measures in excess returns and risk-adjusted returns almost across lookbacks. This highlights that there is significant result variation with different country samples as the inflation measure has been until this finding been the best-performing measure portfolio across the board. Besides this finding, the measure portfolios formed from the rest of the sample countries show slightly different dynamics than with the aggregate sample across lookbacks, also the aggregate term portfolios formed from the rest of the countries generate higher excess returns than the G4 or the aggregate sample due to the increased performance of the economic activity and combo measures within that sub-sample. The G4 performance is relatively in line with main results with the most notable finding being that the currency-hedged economic activity and combo measures underperform the total samples similar measures slightly. From this I conclude that most of the inflation measure's performance comes from G4 sovereign bonds while the economic activity and combo measures generate returns mostly from the rest of the sample. Even so, country-selection bias can result in differing results when analyzing the macroeconomic momentum investment strategy in the government bond market.

Figure 22. The cumulative excess returns of currency-unhedged measure portfolios of G4 (left-side) and the rest (right-side). (From top to bottom) 1st row: Long-short measure portfolio and benchmark cumulative excess returns **2nd row:** Cumulative excess returns of the long positions of the measure portfolios. **3rd row:** Cumulative excess returns of the short positions of the measure portfolios. **4th row:** Cumulative excess returns of the aggregated term portfolios.

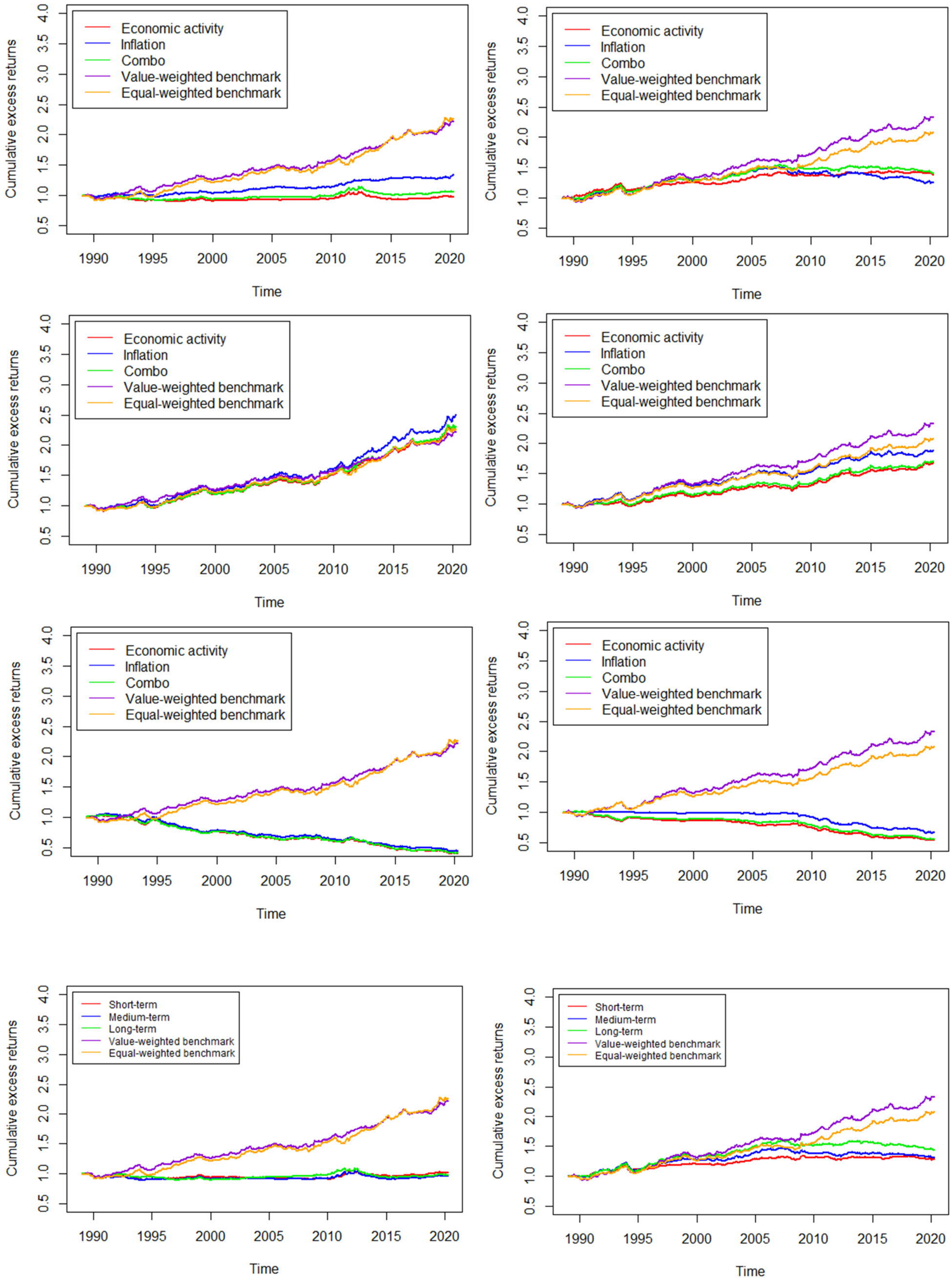
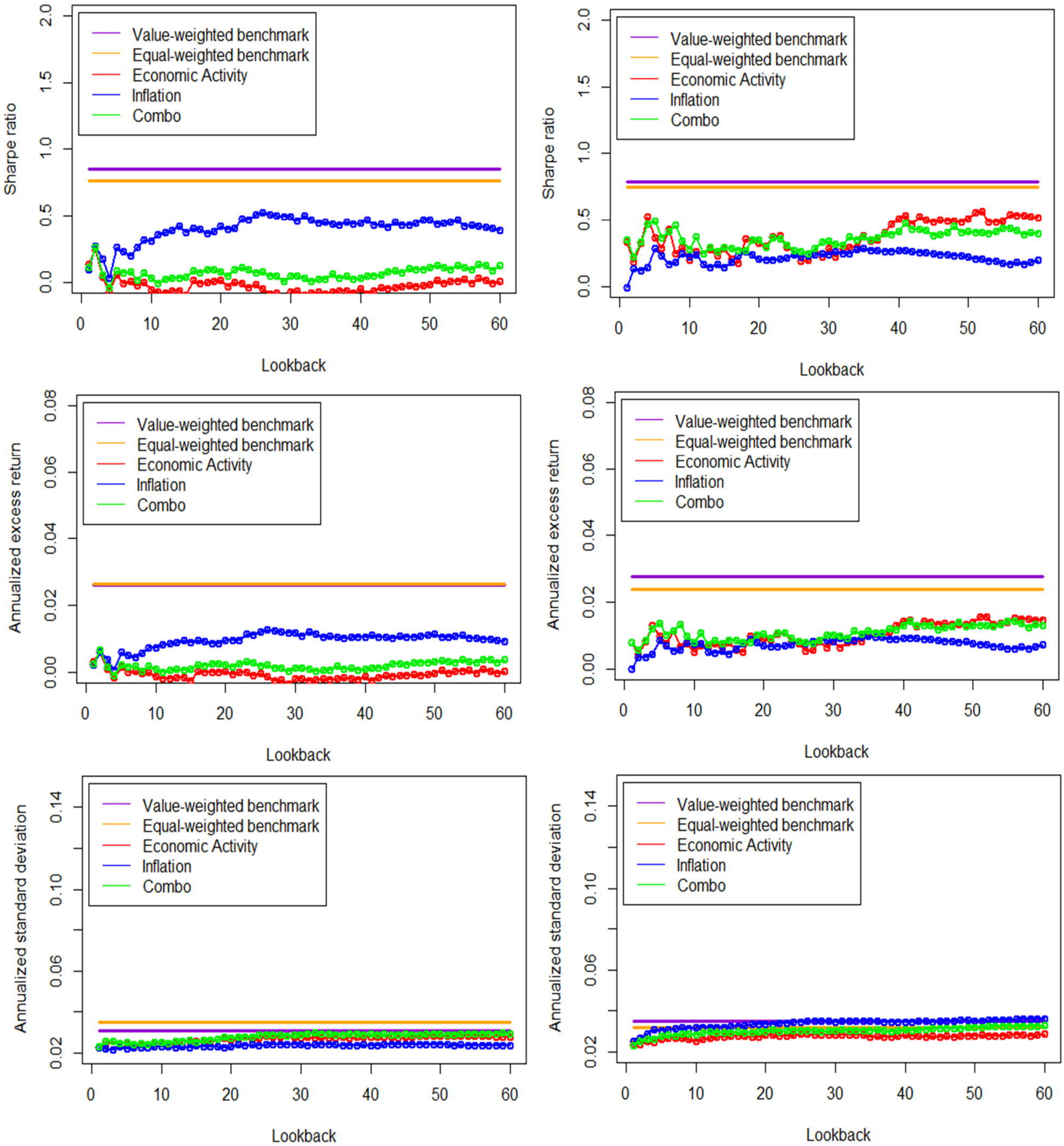


Figure 23. The mean annualized excess returns, standard deviation and Sharpe ratio of measure returns per lookback (G4 = left-side, rest = right-side) Top: Annualized Sharpe ratio. **Middle:** Mean annualized excess returns. **Bottom:** Annualized simple standard deviation of returns.



8 Discussion

With regard to my research questions, the macroeconomic momentum strategy shows significantly weaker performance in the government bond market compared to the FX market, as the value-weighted bond market index outperforms all but the inflation measure portfolio in currency-unhedged returns. The economic activity and combo measures performed significantly weaker compared to the inflation measure across the board, and the aggregated term portfolios also showed poor performance with longer lookbacks performing better than shorter ones. Also, the returns are mostly driven by bond and FX market exposure and FX macroeconomic momentum returns rather than bond zero-cost factors, especially carry, which questions whether the strategy actually can generate any meaningful returns when also taking the complexity of its implementation. Even as the performance of the strategy is quite muted in the government bond market when FX risk is eliminated, I still manage to provide quite substantial support for my hypotheses that carry and negative value are captured by it.

The results support my hypothesis of the carry factor being a consistent return driver of the macroeconomic momentum strategy across measures and lookback lengths. Especially the inflation measure shows a stronger link with carry which can be argued to happen due to an inflation-specific phenomenon which steepens sovereign yield curves. Such phenomena could be rising interest rate expectations due to the expectations theory as higher inflationary pressures influence central banks to tighten their monetary policy by most commonly raising the policy rate. However, as Ilmanen and Iwanowski (1997) point out, the market is empirically poor in predicting future interest rate levels, an alternative argument could be that higher past inflation rates increase some risk premia based on the liquidity preference theory, i.e. the inflation risk premia. As Christensen et al (2010) find that inflation risk premia have been near-zero in the past years, their potential seems relatively weak. Instead, the most promising inflation-specific phenomenon that steepens yield curves is expected inflation rates, that are according to Frankel et al (1994) and Diebold et al (2007) embedded in sovereign yield curves. Unfortunately, historical inflation expectations are difficult to model, especially on a multi-country level, as survey data is limited by availability and several financial instruments which currently exist for investors to hedge or speculate with future inflation rates, e.g. inflation-linked bonds and inflation forwards and swaps, have price data for a very limited time frame and geographical sample. (Binder, 2016) Therefore, the classic and relatively naïve model for inflation expectations is the model of Fisher (1925 & 1930), which states that inflation expectations follow past inflation data and is according to Andersen et al (2003) a good predictor of expectations, and which however supports my findings: past inflation trends increase inflation expectations, which steepen yield curves, and improves the performance of the macroeconomic momentum strategy's performance in the government bond market. As e.g. Smets et al (1994), Diebold et al (2007) note, expectations of economic output indicators also influence the steepness of sovereign yield curves, which also is supported by my findings that the economic activity and combo measures also are affected by the carry factor, even as the effect is weaker than for the inflation measure. Overall, the influence the carry factor has on the macroeconomic momentum strategy in the government bond market is in line with the findings of Dahlquist and Hasseltoft (2019) in the FX market as they find it to be the strongest zero-cost factor affecting the strategy's returns out of the other two factors they test, value and price momentum.

My second hypothesis of the value factor also being a consistent return driver of the macroeconomic momentum strategy is supported by my test results, as the factor receives consistently slightly negative coefficient estimates that show robustness across measures and term portfolios, both in currency-unhedged and currency-hedged returns. As the macroeconomic momentum strategy goes long in countries that have experienced positive macroeconomic trends, and probably increasing yields, and the value strategy goes short in countries with the most increased yields in the past, the negative correlation between the strategies is evident. However, as negative macroeconomic signals could also trigger rising yields, and therefore price depreciation of bonds, in the case of for example a rising default probability of an economy, the allocations of the macroeconomic momentum portfolios and the value portfolio sometimes potentially take also similar positions. Therefore, the value factor's robustness is not on the same level as for example the market factor or the carry factor's robustness. The finding of a negative coefficient estimate for the value factor is also somewhat in line with Dahlquist and Hasseltoft (2019) findings where the factor receives a negative but statistically insignificant coefficient estimate. The reason for why the factor shows strong robustness in the government bond market lies potentially in the fact that value measures for the government bond market are sensitive to measurement errors. (Asness et al, 2013)

The most interesting and unexpected test results however is that the macroeconomic momentum measure portfolios are dramatically exposed to systemic risk: in general, bond and FX market factors influence the strategy's returns predominantly compared to the zero-cost factors of carry, price momentum and value Dahlquist and Hasseltoft (2019) used to test the strategy's returns. This raises the question whether there is any reasonable alpha to reach for by implementing the strategy in the government bond market, or potentially even in the FX market contradicting Dahlquist and Hasseltoft's findings, as past macroeconomic trends are potentially heavily priced-in by the market. The high market exposure is potentially explained by Diebold et al (2007) and Driessen (2000) finding that sovereign yields correlate highly together through a 'global factor'. In the government bond market only the currency-unhedged inflation measure portfolio shows some signs of a positive and statistically significant alpha, but that alpha is diminished immediately when the FX risk is eliminated by testing currency-hedged portfolio returns, while the initial signs of the alpha could also be influenced by a slightly biased model. However, it seems to be possible to achieve alpha with the macroeconomic momentum strategy in other asset classes as well by benefitting from the FX risk: for example, investing in equities or corporate bonds that are denominated in a specific currency. Even as the market potentially prices-in past macroeconomic trends, the market exposure can be diminished by diversifying across measure portfolios, preferably within similar lookbacks, as the market factor coefficients show much weaker correlation with the term portfolios compared to the measure portfolios.

The robustness checks show that the strategy's return drivers are somewhat vulnerable to selection bias with regards to the sample's timeframe. Carry shows persistency across the total sample's time frame while the bond and FX market factors show weakening robustness when sub-samples move closer to the end of the total time frame, and the value factor has received a robustness boost since the Great Financial Crisis which saw central banks implementing unconventional monetary policy actions such as quantitative easing and negative interest rates, which have affected the government bond market substantially with sovereign yields falling to their record lows and central banks buying trillions of USD worth of sovereign bonds. The actions have flattened sovereign yield curves which can be seen as lower carry returns and factor loadings, the fall in the market factor's coefficient estimates potentially happens due to the overall fall in interest rate levels or the implementation of quantitative easing as central banks are not as price-sensitive as other investors. Also, the performance of the macroeconomic momentum strategy is heavily influenced by the selection of countries used in the investment universe. The G4 sub-sample of countries showed drastically lower returns that the sub-sample consisting of several developed economies as well as EM economies. This potentially highlights the growth factor nature of the strategy, that can also be seen as the robust link with a positive carry factor and a negative value factor.

Feasibility of a long-short government bond portfolio

The long-short portfolio's status as the framework for a macroeconomic momentum investment strategy could be questioned based on my findings in the government bond market as the short-positions constantly generate negative excess returns even as they provide diversification benefits. The main aim of the long-short portfolio framework is to make the macroeconomic momentum portfolios market-neutral investment strategy that can be compared with market-neutral portfolios similar to the carry, price momentum and value portfolios, but in the context of implementing the strategy in the government bond markets that is not the case as the long-short macroeconomic momentum portfolios are substantially correlated with the market factor. The FX markets where the strategy was first studied by Dahlquist and Hasseltoft (2019) does not have a universally acceptable measure for a market factor as for example the equity or government bond markets which could affect the results that Dahlquist and Hasseltoft reported in their study. The failure of the market-neutrality of the macroeconomic momentum bond portfolios could also be simply an issue specific to the government bond markets, but further research in other asset classes is needed to solve this issue. A long-only bond portfolio however seems to be a more attractive option from an investor's point-of-view as the excess returns are on average higher with similar risk-adjusted returns than the value-weighted market index when the FX exposure is not hedged for. Also the feasibility of implementing the strategy in practice would be better with a long-only portfolio as short-selling large amounts of bonds, even from the most liquid sovereign issuers, has more opportunity costs than short-selling other asset classes such as FX or equities.

Transaction costs

As with all investment strategies with actively rebalanced portfolios, transaction costs are an issue not considered by most investment strategy literature. For the macroeconomic momentum bond portfolios the transaction costs would probably pose an issue as the number of transactions would be significant if the strategy would be implemented similar to the measure portfolios I studied, as the measure portfolios consist of 60 sub-strategies that have in total at most 26 countries which's bonds the investor should transact each month. The actual number of transactions needed for rebalancing on average is hard to calculate as in practice the different sub-strategies' weights of a measure on a country would be cancelled out by the measure's other sub-strategies' weights etc. and the number of different bonds to transact to replicate the Bloomberg Barclays total return indices is also hard to analyze without transacting all the individual bonds of the indices. There are ETF's that replicate some Bloomberg Barclays total return bond indices, however those are not available for all the countries I included in my sample, so replicating the strategy in practice would probably require transacting numerous individual bonds at every rebalance.

The transaction costs in sovereign bond markets varies greatly with the maturity and issuer, e.g. the market for on-the-run U.S. Treasuries is in general one of the most liquid markets in the world, while off-the-run bonds of an emerging market economy would be more costly to acquire in general. In any case, the transactions costs would consume a lot of the excess returns that the macroeconomic momentum government bond strategy would generate, and which would make it relatively unattractive as an investment opportunity.

Indications for further research

As this study is among the first ones to analyze the macroeconomic momentum investment strategy alongside the study of Dahlquist and Hasseltoft (2019), further research in other asset classes, e.g. equities, would shed light on the question whether macroeconomic momentum is mostly an FX-market-based strategy. In the government bond market a similar setting as in the FX markets shows very limited results compared to the findings of Dahlquist and Hasseltoft so a different approach in the government bond market could potentially affect the results in a positive way as e.g. the long-short portfolio's framework does not generate positive excess returns in any portfolio's case. Also the results of the strategy's performance in the FX markets could be appended by adding some market factor to the dependent variables of the linear regression models, as the results in the government bond markets suggest that the strategy is heavily influenced by market movements. Additionally, several issues with selection bias could be studied further. As I show that the performance and drivers of the macroeconomic momentum strategy in the government bond markets is relatively sensitive to sample selection; different time periods and country samples could alter the results greatly also in the FX markets. Also, the strategy's return drivers could be analyzed in more detail also in the government bond markets as the asset class is probably the most prominent one to show evidence of macroeconomic momentum due to the macro sensitivity of sovereign yield curves. For example disaggregating the market factor into risk premia could open up the black box of the market factor; for this sample the estimation of several mathematically modelled risk premia like the inflation risk premium, liquidity premium and sovereign risk premium were unable to be modelled as most of the countries lacked the required data.

9 Conclusions

This thesis serves as the first extension to Dahlquist and Hasseltoft's (2019) study of the macroeconomic momentum investment strategy by researching its performance in the government bond market. Similar to the FX market, the strategy robustly captures government bond carry factor positively and statistically significantly while it shows a weak link to traditional price momentum. The carry effect is more pronounced with the inflation measure due to some inflation-specific phenomenon, such as it predicting higher inflation expectations or inflation risk premia, or due to the fact that most central banks target inflation, higher interest rate expectations. The strategy captures also a robust negative value factor contradicting Dahlquist and Hasseltoft's (2019) findings in the FX market, which is potentially due to the methodology of how the government bond value factor is calculated based on Asness et al (2013) and the macroeconomic momentum being structurally negatively correlating with it. The linkages between macroeconomic momentum and both carry and value are also robust with smaller time frame sub-samples.

The performance of the strategy in the government bond market is in general muted compared to the market index and no robust alpha can be found with the same linear regression models Dahlquist and Hasseltoft (2019) find evidence of it. The main reason for this potentially lies in the very significant market factor exposure of the strategy across the board: the market is heavily pricing-in past macroeconomic trends. This also casts some doubts on Dahlquist and Hasseltoft's (2019) results that the strategy could provide investors with economically significant positive alpha in the FX market, as they do not control their regressions with a market factor, like the DXY index, which could show if the FX market prices-in past macroeconomic trends. However, further research of the strategy's performance in other classes potentially serves as a fruitful extension in the literature of macroeconomic momentum as investors could benefit from the interesting FX exposure provided by it. Moreover, the performance of the macroeconomic momentum strategy in the government bond market is predominantly driven by bond and FX market exposure and FX macroeconomic momentum rather than bond zero-cost factors of carry, value and price momentum.

Growth factor is a key driver of the strategy's performance based on the robust positive carry and negative value factors, as well as the underperformance of the G4 sub-sample compared to a sub-sample including EM economies. This is similar to Dahlquist and Hasseltoft's (2019) findings in the FX market, and probably the most summarizing unifying factor between the strategy's performance across asset classes.

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